VOLUME L NUMBER 1

THE HAWAIIAN PLANTERS' RECORD

New Insect Pests in Hawaii

Upper: *Polydesma umbricola.* Causes serious injury to monkey pod trees.
Lower: *Anacamptodes fragilaria.* Heavily defoliates leguminous forage plants.

FIRST QUARTER 1946

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Stalk Counts of 32–8560 in the Field at Lihue*

By W. S. Barnes
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This is a progress report on an investigation of the somewhat disappointing results obtained from 32–8560 under certain conditions at The Lihue Plantation Company, Ltd. It should be stated at the beginning that these conditions may be peculiar to Lihue at the time, and that the results obtained may not happen again.

These comments and figures are merely recorded for the information of others who may have similar problems, or who may be able to offer plausible explanations for the results obtained.

In March of 1945 we became alarmed over the excessive dead and dying primary stalks found at harvest, and the resulting poor purities reported at the mill. The cane was from fields of 32–8560 ratoons, 23 to 24 months old at harvest, and had tasselled heavily the first winter at 9 to 10 months of age. The management asked that a study be made in these fields to determine the cause or causes which so seriously affected the condition of the primary stalks.

After discussing the matter with H. K. Stender, Island Representative of the Experiment Station, H.S.P.A., the following procedure was set up and followed:

Procedure:

We selected representative areas from burned cane in each of three fields under study, taking 10 running feet of line. The cane from these ten feet was divided into three groups—primaries (all first-season cane), suckers (second-growing-season cane), and others (millable cane of third-season growth). Each stalk was studied and its condition recorded individually.

We then took gross cane weights of the primaries, secondaries, and third-season cane separately. The cane was transported to our Cuban mill, and the three categories crushed separately. Separate juice weights and analyses were made, and later a sample from all juice from each 10-foot section was analyzed.

* Presented at the Annual Meeting of the Hawaiian Sugar Technologists, December 20, 1945.

Discussion of Results:

A tabulation of the figures obtained at harvest time is given below:

	Primaries	Secondaries
Tasselled	33%	41%
Sound stalks	9%	70%
Damaged	15%	6%
Dying	49%	12%
Dead	27%	12%
Cane per acre	47.6 tons	42.3 tons
Q.R.	19.6	6.7
Sugar per acre	2.43 tons	6.31 tons

In the primaries (first-season cane) it was impossible to determine whether or not 37 per cent of the stalks had tasselled, because of such an advanced state of deterioration. Among those that definitely had tasselled, 9 per cent failed to lala. However, all lalas were poor and also in the process of dying. The non-tasselled primary stalks were in equally poor condition with 40 per cent dying and 20 per cent dead. They were so poor and spindly, with weak tops, that only 10 per cent could be considered sound.

The secondaries (second-season cane) were much stronger and sounder and even although there were twice as many canes of the primary as of the secondary type, the cane tonnage was almost equal and the sugar yield was 2.6 times as great, with the result that 72 per cent of the sugar yield came from the secondaries.

After completing this study we decided to compare results with a plant 32–8560 field that had gone through the same crop cycle. As anticipated we found less second-season growth, less tasselling and sounder primaries. The tasselled primaries had good lalas, and the non-tasselled stalks had continued good growth to harvest. The primaries were larger in diameter and longer than in the ratoons. The second-season growth was lighter than in the ratoons, probably due to the heavy, vigorous primary growth which successfully shaded out many suckers. It is felt that this lighter secondary growth was the main contributing factor to the good lalas and sound primaries at harvest.

Here are per cent comparisons of plant and ratoon results:

	Plant	Ratoons
Of total weight—primaries contributed	66	52
Of total weight—secondaries contributed	34	48
Of total juice—primaries contributed	66	50
Of total juice—secondaries contributed	34	50
Of total T.S.A.—primaries contributed	56	27
Of total T.S.A.—secondaries contributed	44	73
Tasselled primaries	14	33
Tasselled secondaries	22	41

Conclusion:

In these fields under study we had apparently harvested two crops: (1) The primary crop which had reached its optimum time of harvest some time after the first winter's tasselling, and prior to the time that immature secondaries began to

impair the juices; and (2) the secondary crop which had reached full maturity at the time of this harvest. It does not appear to be an economical practice to harvest 48 tons of cane to realize 2.4 tons of sugar.

The question that naturally arises is "What can we do about it?" Are our cultural practices partly to blame, or has our study merely uncovered variety characteristics?

We do know from our own observations and from Experiment Station, H.S.P.A., reports that 32–8560 is potentially a heavy tasseller. We know also that stalk splitting is a common occurrence as well as heavy suckering.

I think it is important that we remember that just as many non-tasselled stalks were dead or dying as tasselled stalks. These non-tasselled stalks had had the jump on the secondaries at one time, and yet many undamaged stalks apparently had died a natural death. This fact leads me to a statement that I cannot substantiate at this time but which I personally believe, and that is *when the secondaries were well on their way, commencing when millable cane formed, they either robbed the less vigorous primaries of available plant food, or actually took nourishment from the primary stalks themselves, or both, as many of the dying but otherwise undamaged primaries were pithy and very dried out.*

From our observation, it appears that, although the majority of the tasselled primaries produced lalas, heavy tasselled, 32–8560 ratoons will not put on sufficient tonnage from lalas to add much to the total tons cane per acre. In addition stalk deterioration of untasselled primaries proceeded at as great a rate as the remaining stalks put on tonnage.

As I have stated earlier, 37 per cent of the primaries had no tops, and the fire had so burned the dead and dying cane in this group, that we were unable to determine whether or not they had tasselled.

With this information before us, it might be helpful to follow the growth of a crop month by month at set stations in a heavily tasselled 32–8560 ratoon field. We chose Field 8 HM, a makai second ratoon 32–8560 field which was ratooned in March 1944. This field tasselled 55 per cent the winter season of 1944–1945. Studies were commenced in March 1945 at which time the cane was one year old.

Three stations were selected in representative areas of the field. Each month we removed 10 running feet of cane from each station. All millable cane was removed, regardless of age or condition. The procedure was the same as that used in our first study, that is, each individual stalk was examined carefully to determine the following facts: (1) Condition of stalk—sound, damaged, dying or dead; (2) condition of tasselling—untasselled, tasselled, or abortive; (3) lalas—number and condition; (4) vigor of growth of stalk—vigorous, spindly or shaded; and (5) miscellaneous data such as rat and borer damage and splitting.

All cane from the three stations was transported to our Cuban mill, and the cane from each station crushed separately, keeping primaries and secondaries (suckers) separate. We then computed T.C.A., Q.R., T.S.A., per cent of the total weight of primaries and secondaries, and per cent sound, damaged, dying and dead. Damaged stalks were those that were severely split, broken, or showed evidence of rat damage, but otherwise were sound at that sampling date. Dying cane was that which showed stalk deterioration, dead or dying tops, or were shaded out. Dead stalks were just that, dead from shading, failure to lala, or any other contributing factors.

When the study commenced the tasselled stalks were just beginning to produce

lalas. We noted that these tasselled stalks constituted the most vigorous primaries in each station. The non-tasselled stalks were more spindly, or had weak short tops. In March there was no millable cane on the suckers, although there were large numbers growing.

As our month-by-month study progressed, we became more and more concerned with the condition and growth of the primaries.

In the tasselled group, which averaged 44 per cent for the entire study, the lalas in almost all cases failed to elongate after the second month, and from then on they began to die back slowly. Many of the dead tasselled primaries observed in the latter part of the study had lalas that had died many months earlier. In our last field observation, made three weeks ago, we found that 50 per cent of the lalas counted were dead and 9 per cent were dying. The remaining lalas were barely able to stay alive and contributed little to the cane tonnage. This condition was similar to that found in our previous study of 32–8560 at harvest.

The untasselled primaries also failed to put on tonnage during the study. In our first observation in March, we found that the untasselled primaries were the weakest stalks in the field. Many were shaded out and were dead by June. Those which continued to grow throughout the crop were spindly and weak topped. Stalk deterioration advanced at a faster rate than tonnage was produced and the tons cane per acre of the primaries actually fell from 72 tons in March to 63 tons per acre in December.

The above information should indicate to you the seriousness of the problem facing us. Fields ratooned in January, February, March or April constitute fully 25 per cent of our annual crop, and if this study is indicative of what we can expect each year, we are in for large sugar losses unless we can cope with the problem. We do not know at this time if heavy tasselling, the main contributing factor to our trouble, can be controlled by (1) time and amounts of nitrogen applications, (2) other amendments, or (3) increased or extended irrigation at the time the tassell head is forming. Our unpredictable rainfall may eliminate the latter.

Immediate study and experimentation is imperative. However, we are hoping that we will soon have a variety of cane to replace 32–8560 under the conditions in which the crops must be grown at Lihue.

Cane Deterioration in a Storage Pile*

By R. L. Wold, Agriculturist
Olokele Sugar Company, Kauai

In a study such as this there seem to be many factors which have a deleterious effect on the purity of the juice, if the cane is stored for any appreciable length of time in a stock pile. Some of these would have more effect than others. The following are a few of the more important ones:

1. Length of time in pile.
2. Moisture content—wet or dry.
3. Original condition of cane—crushed, dead cane, ripeness.
4. Size of pile.
5. Amount of extraneous matter—dirt, trash, tops, etc.
6. Length of time burned before piling.
7. Temperature and humidity.

To determine the proportionate effect of each of these would entail a tremendous amount of work. The more pertinent ones were decided upon and a study made to determine their relative effects on juice purity. First, however, let us take a look at these factors and consider what effect each might have.

1. Length of Time in Pile:

This, without much doubt, is the number one factor and it goes without saying that the shorter the time the cane is in storage, the better. It is only logical to suppose that during the first 24 hours the chemical reaction of inversion has not attained the speed that it will have at the end of, say, 48 or 72 hours. From our plantation experience with cane storage, there is not much effect on juices during the first 24 hours provided the other factors are near ideal. These factors are discussed later.

2. Moisture Content—Wet or Dry:

Most of the inversion and consequent deterioration of juice purities is due to bacterial activity. Moisture with its subsequent dilution of juice adhering to crushed stalks will promote and accelerate this activity. Hence, it is only logical that wet cane put in a large storage pile will deteriorate faster than if it were completely dry.

3. Original Condition of Cane:

We assume that the more crushed and mutilated the cane stalks are when they are put in the stock pile, the faster the purity will drop. The mangling of cane under present harvesting methods is certainly a factor to consider when cane is to be stored for any length of time. The amount of dead cane, half-sour stalks and immature cane are other conditions which will have their ultimate effect.

* Presented at the Annual Meeting of the Hawaiian Sugar Technologists, December 20, 1945.

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4. Size of Pile:

From our experience with cane storage, a large pile of cane will deteriorate faster than a small one. The pressure and increase of temperature which can take place in a large pile would quite logically accelerate deterioration.

5. Amount of Extraneous Matter:

A poor burn which favors lots of green tops, damp trash and dirt is certainly undesirable, but very little can be done usually about this factor except to try and control the size of the pile and length of time the cane is to be stored.

6. Length of Time Burned Before Piling:

This is merely another time factor, and from a wealth of past experience we all know that time is the biggest single factor to fight in preventing juice deterioration.

7. Temperature and Humidity:

Since the inversion of sucrose is essentially bacteriological and chemical in nature and since temperature is such an important factor in reactions of this type, an increase in temperature of but a few degrees will have a marked effect on the rate of bacterial growth and consequent juice deterioration. A warm humid condition within the cane pile is a favorable environment for a drop in purity.

To pin evidence on some of these factors, two studies have been made; the first of these was merely a time experiment which was conducted in the following manner:

In November 1945 a pile of cane amounting to about 100 tons was set aside, and 25 tons of this cane was ground each day for four consecutive days and juice samples taken. The cane in this test was 32–8560 from a good burn, had been harvested about 24 hours when piled, and was fairly free of dirt and trash. The following is a summary of results:

	Brix	Pol	Purity
First day	15.70	13.86	88.3
Second day	15.91	13.93	87.6
Third day	15.87	13.36	84.2
Fourth day	15.47	12.93	83.6

Although the drop in purity here is not as rapid as the one secured in our later test, it does show that there is appreciable deterioration and indicates that to store cane for much more than 24 hours is rather expensive.

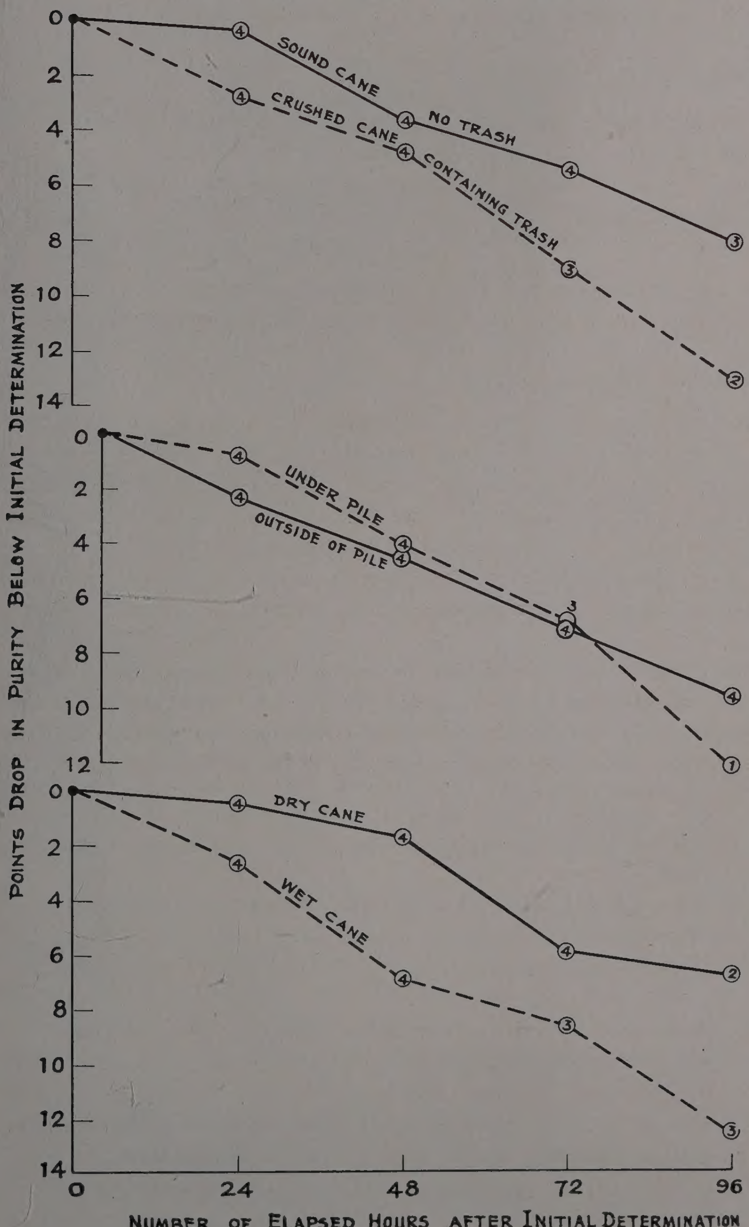
The second of these studies was a little more elaborate. However, this test should have been repeated once or twice to lend more weight to the indications found. The following is a description of this study with the results. The object was to secure a quantitative measure of the more important factors such as time, moisture content and original condition of cane.

A total of 25 carefully selected and similar stalks about 3 feet long was placed

DROP IN PURITY OF JUICE DURING STORAGE OF CANE

FIGURES IN CIRCLES ARE NUMBER OF DETERMINATIONS IN AVERAGE.

INITIAL PURITY AVERAGE = 87.5 (APROXIMATE)



in a burlap bag to constitute each sample. The following treatments were then imposed:

X: Outside of pile
Y: Under pile

A: Wet—sound, no dirt or trash
B: Dry—sound, no dirt or trash
C: Wet—average per cent damage, plus dirt and trash
D: Dry—average per cent damage, plus dirt and trash

0: Immediate
1: 24 hours
2: 48 hours
3: 72 hours
4: 96 hours

The complete setup of treatment was as follows:

OUTSIDE OF PILE				UNDER PILE			
Wet		Dry		Wet		Dry	
XA0	XC0	XB0	XD0	YA1	YC1	YB1	YD1
XA1	XC1	XB1	XD1	YA2	YC2	YB2	YD2
XA2	XC2	XB2	XD2	YA3	YC3	YB3	YD3
XA3	XC3	XB3	XD3	YA4	YC4	YB4	YD4
XA4	XC4	XB4	XD4				

These 36 samples were ground at the proper interval in a small 3-roller Cuban mill and juice analyses made. The cane for this test was 32–8560 harvested by rake and hauled to the mill yard and stacked. The samples were then cut from this pile of stacked cane. The cane had been burned on Saturday, and was hauled on Monday and samples taken; thus it had been cut about 48 hours when the test was started. The "average per cent damage" stalks had at least one crushed joint per stalk, and some had two injured ones. The approximate damage in this treatment was 25 per cent.

On the last day of the experiment the crane operator by mistake put three of the four samples remaining under the stock pile through the mill, so YB4, YC4, and YD4 were lost. A maximum recording thermometer was buried inside one of the bags under the stock pile, with the following recorded maximum temperature: First night—92, second—78, third—73, and fourth—74. Why the temperature was so high on the first night could have been due perhaps to the heating of the stalks as they were exposed to the sun during the selection of samples.

The bags were laid on the cement platform and the cane piled on top of them. In every case the samples were placed one day and by the following morning the pile was all removed and the bags placed under a new pile. This was not an ideal arrangement in that an undisturbed period was not secured. Fresh cane piled on top each day would hardly give the same temperature and humidity conditions as in an undisturbed pile. In each case a pile of at least 500 tons was stacked on top of the bags making a pile about forty feet high.

There had been a rain a few days before the harvesting of the cane used in this test. The burn was only fair and there was considerable dirt and trash with the cane. The following is a summary of juice analyses:

	Brix	Pol	Purity	Q.R.	
XA0	19.13	17.03	89.02	7.81	
XA1	19.94	17.32	86.86	7.80	
XA2	18.30	15.31	83.66	9.08	Outside of pile—wet—sound—no dirt or trash
XA3	18.93	15.53	82.04	9.09	
XA4	18.25	15.10	82.74	9.29	
YA1	19.60	17.29	88.21	7.74	
YA2	18.57	15.31	82.44	9.19	Under pile—wet—sound—no dirt or trash
YA3	19.25	15.51	80.57	9.23	
YA4	18.73	14.40	76.88	10.35	
XB0	18.37	16.09	87.59	8.35	
XB1	19.51	17.22	88.26	7.76	
XB2	19.63	16.68	84.97	8.24	Outside—dry—sound—no dirt or trash
XB3	19.30	16.40	84.97	8.38	
XB4	20.58	16.86	81.92	8.38	
YB1	19.51	17.22	88.26	7.76	
YB2	19.38	16.95	87.46	7.94	Under pile—dry—sound—no dirt or trash
YB3	19.35	16.46	83.51	8.62	
YB4		(No sample)			
XC0	18.89	16.65	88.14	8.04	
XC1	19.05	16.01	84.04	8.66	
XC2	18.00	14.37	79.83	10.64	Outside—wet—crushed—dirt and trash
XC3	17.42	13.61	78.13	10.80	
XC4	16.31	11.36	69.65	14.45	
YC1	18.04	15.28	84.70	9.01	
YC2	18.69	15.10	80.79	9.46	Under pile—wet—crushed—dirt and trash
YC3	17.45	(Too sour and turbid to read)			
YC4		(No sample)			
XD0	17.60	15.04	85.45	9.09	
XD1	18.29	14.96	81.79	9.46	
XD2	18.88	15.75	83.42	8.85	Outside—dry—crushed—dirt and trash
XD3	19.64	15.09	76.83	9.89	
XD4	20.03	15.54	77.58	9.51	
YD1	18.58	15.93	85.68	8.57	
YD2	18.88	15.75	83.42	8.85	Under pile—dry—crushed—dirt and trash
YD3	19.02	14.64	76.97	10.21	
YD4		(No sample)			

From these results a few trends are indicated and attention can be called to the following points:

1. The amount of moisture and original condition of cane appear to have had greater influence than whether or not the cane samples were piled in the storage pile or on the outside.

2. Sound, clean, dry cane deteriorates much slower than cane which is damaged, dirty, and wet, as, of course, we would expect to be the case. What seems strange is the relatively small difference between stock pile samples and those left in the

open air with no cane on top. Again the fact that fresh cane was piled on top of the samples each day instead of their remaining under an undisturbed pile may have been the chief factor in keeping these differences so small. The heat generated in the short period of time that the pile remained on top of the samples was not sufficient to be of any consequence in this study.

3. In cane that is damaged, such as most of it is with the present harvesting methods, deterioration sets in almost immediately and the rate of this is greatly accelerated by moisture. If mechanically harvested cane is to be stored for any length of time longer than 24 hours before grinding, there will result a disastrous loss of recoverable sugar, especially if the cane is wet. With mechanical harvesting it appears logical that, whenever possible, operations should stop during very rainy weather.

Recent Immigrant Insects

By R. H. Van Zwaluwenburg

During the last year and a half of the war fifteen insects new to the Hawaiian Islands, and apparently recently arrived, have been found here, the majority of them firmly established. It is believed that some of these new immigrants reached Hawaii as a direct result of airplane traffic, which during the war increased far beyond normal.

During the nineteen months which elapsed between the summer of 1944 and early 1946, fifteen insects new to the Hawaiian Islands, and apparently recently arrived, have been found here, the majority of them firmly established. Their discovery in most cases was due to the systematic use of light traps (a modified type of the New Jersey mosquito trap). These were operated primarily at or near large airports, on the chance of discovering as soon after arrival as possible any new insects which might get here alive in airplanes. The U. S. Navy operated traps first under the direction of Lt. W. M. Herms, U.S.N.R., and later of Lt. R. D. Eichmann, U.S.N.R. At the same time the U. S. Public Health Service made extensive use of light traps operated by W. W. Wirth, Passed Assistant Sanitarian (R.). In these light traps over 150,000 insects were collected; these were identified by Experiment Station, H.S.P.A. entomologists.

Inspection by quarantine officers of incoming planes had long made clear the insect hazards to which this Territory was being exposed by air transport. Because of the war, of course, air traffic was greatly augmented; it is estimated that during the peak months of 1945 from 1,200 to 1,500 planes arrived each month at Hawaiian airports from outside the Territory. The finding of new insects in the light traps greatly stimulated interest in the quarantine work, and led to marked improvement in quarantine measures. This local wartime work was of the greatest interest to mainland authorities, for every new insect pest established in these Islands adds just so much more to the quarantine problems of the continental United States.

Although it is difficult, if not impossible, to prove that any one insect species has become established here as a result of airplane transportation, we believe such to be the case in one or more instances. For example, *Achaea* adults were found more than once in planes arriving at Honolulu from other parts of the Pacific months before the moth was found to be established here.

None of the insect immigrants found within the past year and a half are pests of sugar cane or any other major crop, but that is merely the Islands' good fortune. The new insects include a grasshopper, a cricket, a mayfly, six moths, a beetle, two wasps, and three flies. Three of the moths are potential pests, while the grasshopper also may eventually prove serious. However, two of the moths are so readily attacked by beneficial insects already present here, it is evident that at least some natural check will be exerted upon them. The moth from southern California has not yet been found to be parasitized in the field here, but the introduction of a wasp

parasitic upon it in its native range has already been effected. Three of the new insects are beneficial—an enemy of the black widow spider, an internal parasite of a common cockroach, and a predator on aphids. The fifteen immigrants in the approximate order of their discovery here are listed below:

Mayfly (*Caenis* sp.)

This, the first representative of the order Ephemerida known in these Islands, was first taken in a Navy light trap at Pearl City, Oahu, on August 9, 1944. Some days before (July 29) C. E. Pemberton found specimens among material taken from an eastbound plane arriving at the Naval Air Station, Honolulu; it is presumed that the insect was then already established, and that the July specimens had entered the plane after arrival. By January 1945 the first specimens of *Caenis* were found in the Manoa district of the city by Dr. D. D. Jensen, and further spread of the insect on Oahu has been reported since. This insect is of no economic importance.

Chironomid Fly (*Chironomus* sp.)

This midge, distinct from the common *Chironomus hawaiiensis* Grimshaw, and from the unnamed, dusky-winged species occurring on Molokai, was first taken at Pearl City, Oahu, in a Navy light trap on or about August 10, 1944. Mr. Wirth has taken additional individuals in a light trap at Lanikai, Oahu.

Anacamptodes fragilaria (Grossbeck)

Adults of this geometrid moth (Fig. 1) were first taken in a Navy light trap at Hickam Field, Oahu, on August 16, 1944, and individuals continued to come to the light for some weeks thereafter. In February 1945 Dr. F. X. Williams reared an adult moth from a caterpillar found feeding on tree tobacco (*Nicotiana glauca*). Later in the same month attention was called to an outbreak of a new insect at Waianae Company, Waianae, Oahu, which proved to be *Anacamptodes.* Then and later at Waianae it caused some damage to leguminous forage trees and shrubs, but even when feeding by the caterpillars was heavy, recovery by the plants always followed. In February 1946 *Anacamptodes* populations were again heavy in certain areas, and it is possible that a seasonal abundance of this moth can be expected each year during the winter months. Investigations during the 1945 outbreak at Waianae showed that the caterpillars feed on over 30 species of plants, distributed among 14 botanical families. However, legumes are favored, particularly kiawe, koa haole and klu (respectively *Prosopis chilensis, Leucaena glauca* and *Acacia farnesiana*). The pale greenish eggs are laid in crevices in the bark, and the caterpillars pupate in the soil.

At present this moth appears to be the most important of all the insects under discussion, for the reason that so far almost no insect enemies have been found to attack it in the field here. The single exception is the predaceous reduviid bug, *Zelus renardii* Kolenati, but this bug alone hardly seems capable of controlling large outbreaks. It seems likely that the comparative scarcity of *Anacamptodes* during the summer is a result of seasonal factors rather than of *Zelus* attack. Under laboratory conditions it has been possible to breed *Trichogramma minutum* Riley on the eggs, and the ichneumonid *Ephialtes hawaiiensis* (Cameron) as well as the chalcid *Brachymeria obscurata* (Walker) on the larvae of *Anacamptodes,* but no para-

Fig. 1. *Anacamptodes fragilaria* (Grossbeck).

site of any kind has yet been recovered from field-collected material.* Late in 1945 N. L. H. Krauss of the Board of Agriculture and Forestry found a new species of *Apanteles,* a braconid, attacking *Anacamptodes* larvae in California; he brought numbers of this parasite to Hawaii, and they have now been released in the field on Oahu.

A. fragilaria is native to southern California where it is said to be common, but to attract little attention. In these Islands it is known from Kauai, Maui, Molokai, Niihau, and Oahu. The species was originally described in the genus *Cleora* (2, p. 194) in 1909, but was later removed (3, p. 29) to the present genus.

Achaea janata (Linnaeus)

This agrotid (noctuid) moth (Fig. 2) is widespread in tropical and subtropical Pacific regions, as well as in Australia and southern Asia. Adult moths have several times been intercepted in planes arriving here from the southwest. The insect was first found here late in November 1944, when Dr. Williams found a caterpillar feeding on weeds in his garden in Honolulu, the pupa of which was later identified by Dr. O. H. Swezey. A few days later an adult moth was captured on the Experiment Station, H.S.P.A. grounds. The species is now established on Hawaii, Kauai, Lanai, Maui, Molokai, and Oahu. A considerable list of host plants has already been recorded in these Islands: castor bean (*Ricinus*), *Euphorbia hirta, E. bifida, E. geniculata,* koa haole (*Leucaena*), kiawe, klu, *Desmanthus*, ornamental croton

* Since the above was written Dr. Swezey has collected *Anacamptodes* larvae in the field on basil (*Ocimum basilicum* Linn.) which were parasitized by the tachinid fly *Frontina archippivora.*

Fig. 2. *Achaea janata* (Linnaeus).

(*Codiaeum*), *Macadamia,* Chinese cabbage, daikon, cowpea and *Polypodium.* Damage to castor bean and Chinese cabbage is sometimes severe; favorite among the legumes appears to be klu. In other countries it is known to feed on an even longer list of plants.

Fortunately this species is readily attacked in the field by parasites already here —the eggs by *Trichogramma minutum* (sometimes almost 100 per cent), and the caterpillars by *Hyposoter exiguae* (Viereck) and by the tachinid flies *Eucelatoria armigera* (Coquillett) and *Chaetogaedia monticola* (Bigot). In our brief experience with this moth under Hawaiian conditions, it, like *Anacamptodes,* appears to be most numerous during the winter months.

Metioche sp.*

This tiny cricket, probably of no economic importance, was first recognized on June 4, 1945, when specimens were taken in a Navy light trap at Hickam Field, Oahu. Considerably earlier, in late 1944, Dr. Williams recalls having swept specimens from grass in his garden in Honolulu. This cricket is known on Oahu from Honolulu to Waianae, and on Kauai, where it was found by Stephen Au.

Eurytoma sp.

This chalcidoid wasp (see Figs. on pages 30 to 36) was first reared in Hawaii by J. S. Rosa on May 18, 1945, from an egg case of the spider *Latrodectus geometricus* Koch, collected on the Experiment Station, H.S.P.A. grounds, Honolulu,

* Recently identified by Dr. L. Chopard as *Metioche vittaticolles* Stal, a species occurring in Samoa.

on about May 11. Within a few days after it was found, it was discovered to be abundant in the Lualualei and Maili Point regions of Oahu, where it was bred from egg-cases of the true black widow spider, *Latrodectus mactans* (Fabricius), as well as from those of *L. geometricus*. The wasp was soon bred in the laboratory in considerable numbers, and shipments for release were made to Hawaii, Maui, Molokai, and Kauai. It is now known to be established on Kauai, Lanai, Maui, and Oahu.

Neither the specific identity nor the country of origin of this *Eurytoma* is yet known. Its dispersal in freight shipments is a comparatively simple matter due to the habit the host spiders have of attaching their egg cases to crates, boxes, etc. For a detailed account of its life history and habits see the article by Messrs. Pemberton and Rosa in this issue of *The Hawaiian Planters' Record*.

Amyna natalis (Walker)

This agrotid moth so far is known in these Islands only on Oahu. It was first taken in a Navy light trap at Hickam Field, May 14, 1945, and later in light traps at Waipio and Wheeler Field. Recently its greenish caterpillars were found feeding on ilima (*Sida cordifolia* and *S. rhombifolia*), on *Waltheria americana,* and on *Abutilon incanum* in the Barber's Point region and at Aiea, at Waipio and near Waimanalo. Some of these caterpillars were parasitized by the braconid wasp *Meteorus laphygmae* Viereck, an enemy of armyworms recently introduced from Texas; others were parasitized by *Eucelatoria armigera,* a tachinid fly. Elsewhere *A. natalis* is recorded from India, Burma, Celebes, New Guinea, Australia, Tonga, Fiji, and Samoa.

Fig. 3. *Polydesma umbricola* Boisduval.

Polydesma umbricola Boisduval

This agrotid moth (Fig. 3) was first found at Kaimuki, Honolulu, June 4, 1945, the caterpillars attacking the foliage of monkeypod (*Samanea saman*). More serious than the foliage damage is the eating out of the young leaf buds by the caterpillars, which accounts, in part at least, for the death of terminal twigs and branches. The caterpillars also attack opiuma (*Pithecolobium dulce*) and *Albizzia lebbek;* possibly still other leguminous trees will be found to be attacked.

The caterpillars are attacked here by several insects—by the predaceous *Polistes* wasps, by the internal wasp parasites *Hyposoter exiguae, Ephialtes hawaiiensis,* and *Brachymeria obscurata,* and by the tachinid flies *Eucelatoria armigera* and *Chaetogaedia monticola.*

Polydesma is now established on Kauai, Maui, Molokai, Niihau, and Oahu. Elsewhere the moth is recorded from West and South Africa, Madagascar, India, Ceylon, Burma, Formosa, New Caledonia, and Guam.

Polemistus luzonensis Rohwer

This very small sphecid wasp was first found in Honolulu by Dr. Williams on the Experiment Station, H.S.P.A. grounds, June 20, 1945. The insect preys upon aphids with which it stores the nests in which its young develop. This wasp was described (4, p. 5) from material collected in the Philippines by Dr. Williams in 1917.

Rhipiphorid beetle (*Rhipidius* sp.)

Eight specimens of this beetle, identified by Dr. Williams, were taken in a light trap operated by Mr. Wirth at Hickam Field and at Ewa, Oahu, at various times from June 27 to August 20, 1945. Its larvae are parasitic in the common semidomestic cockroach, *Blattella germanica* (Linnaeus), a parasitized example of which was found by Dr. Williams on January 25, 1944, among material collected from a plane arriving at Honolulu from the south Pacific.

Paraidemona mimica Scudder

This wingless grasshopper (Fig. 4) was first collected by Mr. Pemberton, July 5, 1945, at Hickam Field, Oahu, where both adults and nymphs were fairly numerous in dry grass. So far it is known locally only from the immediate vicinity of its first capture. It was described (5, p. 43) from Texas. Although there are no records of its economic importance, it remains to be seen whether or not it will cause damage here.

Unidentified Geometrid Moth

A single unidentified specimen was caught on August 23, 1945, in a light trap operated by Mr. Wirth at Kaneohe, Oahu. It is unlike any species previously known here, according to Dr. Swezey.

Unidentified Otitid (Ortalid) Fly

A single specimen was taken December 3, 1945, in one of Mr. Wirth's light traps at Lanikai, Oahu. Dr. Williams identifies it as near *Euxesta* sp.; it appears identical with a species collected in the Marianas.

Fig. 4. Adult male of *Paraidemona mimica* Scudder.

Unidentified Agrotid Moth

An agrotid moth of the subfamily Acronictinae, known only from light trap captures, has been taken several times on Oahu. It was first taken on December 18, 1945, at Hickam Field, and was later collected at Kalihi (Honolulu), Waipio, Wheeler Field, and Kahuku. Nothing is known of its food plants or habits.

Volucella near *johnsoni* (Curran)

Dr. Williams first took this syrphid fly late on the afternoon of February 3, 1946, in Honolulu on *Dracaena* blossoms, on which it occurred in considerable numbers. The species to which it is tentatively assigned was described from Venezuela (1, p. 249).

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Harvesting Controls

By R. J. Borden

A better knowledge of the actual changes that are taking place in a field of sugar cane as it grows should make it possible to harvest crops carrying the maximum amount of sugar which has come from the combined growth factors the crop has received. By using a plan in which representative samples of the crop were studied periodically to watch for changes in the stalk population and also for changes taking place in the composition of the juices, facts have been recorded that show the actual status of the crop development. Similar facts collected from representative cane samples would provide a good harvesting control and guide decisions as to which field to harvest next.

Greater efficiency in the recovery of sugar from cane stalks has been the result of good mill-control methods, and well-founded control procedures are available all the way from the time the cane arrives at the mill until the sugar is in the bag. In growing the cane too, there are certain field controls which have contributed much to field efficiency. I might mention (1) variety control through Grade A field testing; (2) fertilizer control through RCM and Mitscherlich soil analyses and by comparative field tests; (3) irrigation control through soil-moisture determinations and stalk growth measurements, and through day-degree summations; (4) rat control through prebaiting and poisoning; (5) insect and disease control by parasites and resistant varieties and seed treatments; and (6) weed control whose present weakness is more in its operation than in its technique. All of these field controls have been established on the basis of carefully conducted research and hence have a solid foundation of facts to support them.

There is one important field operation which does not always have this foundation of fact; I refer to harvesting. Many of the harvesting schedules are quite arbitrarily made out several months before the actual harvesting season starts, and they are usually followed with but few changes. They are most generally based upon the age of the cane involved, and under normal conditions the oldest cane comes off first. Convenience has its influence too, with economical considerations being involved in many decisions. These may all be good reasons for the schedule which is decided upon, but are they good enough to offset the fact that they might result in our not getting the maximum results from the cane crop we have so carefully controlled up to this time of harvest?

I think most of us feel that there is an optimum age at which to harvest a cane crop, and some of us believe that this optimum may be different for different varieties. However, I don't think we *know* that this will be true. Also, this optimum age can be different for crops started at different times of the year. For instance, in a study of H 109 plant cane at Waipio (Expt. 101 AH), we found that from crops started between January and August, the maximum sugar yields came at 22 to 23 months and the next best yields at 20 to 21 months of age, but from crops

started between September and December the best yields came when they were harvested at 24 to 25 months and the second best yields at 22 to 23 months.

We are all aware that there are many different factors which influence the growth and composition of a crop of cane. We do not always know, however, to what extent these factors collectively affect the recoverable sugar content. There is only one way to find out, and that is to sample the crop sufficiently to record measurements of conditions that are actually affecting the yields. Our agriculture is not fully efficient if after we have obtained a certain amount of recoverable sugar in the crop, we then lose it in the field by delaying the harvest; nor can we expect to recover the optimum yield of sugar if we cut the crop before its maximum sugar potential is reached. Thus we have need for a better harvesting control that will furnish guidance at a very critical point in our field operations.

The basis for the controlled harvesting plan which suggests itself comes from a mass of data which was collected from an experiment* in Waipio Field 28. The area was planted in February 1943 with 32-8560 cane which got off to a slow start because of delays in weed control but was subsequently fertilized and irrigated adequately. In June after the stand of cane was well established, 20 harvesting zones were established within the field boundaries, and within each of these zones eight sampling stations, each of ten feet of row, were "pinned out." These stations were carefully chosen and contained full stands and comparable growth, and their positions were staggered within the zone so that the harvesting of any one of them would not affect another.

Beginning at six months and at three-month intervals thereafter until the crop was 27 months old, *all* of the cane growing within one of the ten-foot sampling stations from each of the 20 harvesting zones was cut for the crop sample. From these 20 cane samples (from a total of 200 feet of cane row) taken at each harvest, we have information about this crop of cane which suggests that certain measurements made from several preharvest cane samples should be very useful for guidance in decisions concerned with harvesting. You should get the idea more fully as we proceed with our discussion.

The stalk population:

With good conditions for germination and growth, the stalk population in a stand of plant cane starts from primary stalks which spring from the buds on the seed pieces and appear above ground in from one to three weeks after planting. Each primary is followed within another four to eight weeks by one or more secondary shoots which spring from the basal nodes of the primary stalk. Usually one and often two of these secondaries will quickly catch up with the growth of its primary, and in many cases will even surpass it, whereas the other secondaries grow for a short time, sometimes even making a few joints of millable cane before passing out of the population within the first five or six months. A third group of shoots, which start out several months after the secondaries have appeared, seldom add many stalks to the crop; these are largely shaded out and their mortality is very high between four and six months.

Sometime around eight or ten months the first of the suckers put in their appearance. These are easily recognized by their large diameter and their rapid erect

* Waipio Expt. 116—By L. R. Smith, Y. Yamasaki, A. Y. Ching, K. Nishimoto, and assistants.

growth. They soon make up a sizeable proportion of the stalk population and contribute considerable weight to the crop.

A second flush of large-diameter suckers forces itself through the heavy trash blanket at about 16 to 18 months; these are often referred to as "bull shoots." If they get their leaves into the sunlight they grow rapidly, but many which start out at this time soon pass out of the picture; those that do come through will naturally be quite immature during the next six months.

Hence, when a crop of sugar cane is harvested there will be stalks of many different ages included in the population, and since age plays a very important role in sugar yields, it is well that we know something about the relative extent or proportions of the major age groups in the crop we are to harvest.

In Table I we have summarized the main features of the stalk census that were recorded from Waipio Field 28.

TABLE I

STALK CENSUS (AVERAGE NUMBER OF STALKS PER FOOT OF CANE ROW)

Stalk classification	Age and month of harvest						
	9 mos. in Nov.	12 mos. in Feb.	15 mos. in May	18 mos. in Aug.	21 mos. in Nov.	24 mos. in Feb.	27 mos. in May
Millable (1) Primaries (3)	3.03	2.63	2.73	2.36	2.30	2.06	1.63
Non-millable (2) Primaries (3)	.04	0	0	0	0	0	0
Dead Primary Stalks (1)	.07	.42	.45	.61	.63	.79	1.03
Tasseled Primary Stalks	0	0	0	0	0	0	0
Millable (1) Suckers	0	.11	.57	.94	1.05	1.19	1.23
Non-millable (2) Suckers	0	1.15	1.33	.42	.65	.67	.80
Dead Suckers	0	0	0	0	.26	.30	.15
Tasseled Suckers	0	0	0	0	0	.23	.12
Total Millable Canes	3.03	2.74	3.30	3.30	3.35	3.25	2.86
Total Live Canes	3.07	3.89	4.63	3.72	4.00	3.92	3.66

(1) With 3 or more internodes exposed.
(2) With less than 3 internodes exposed.
(3) In this census, primaries include all stalks which were found within the first 3 or 4 months.

Our special interest in this stalk census started when the crop was 12 months old, when we found a considerable mortality of the primary stalks and also the initial appearance of suckers. Thus approximately 14 per cent of the primary stalks had already died, and there is evidence that slightly more than 30 per cent of the total living canes were suckers which had become part of the population between 9 and 12 months.

As the crop increased in age, there was an increase in the numbers of dead primaries, between 15 and 18 months and again between 21 and 24 months. The highest mortality was identified at 27 months when fully one-third of all the primary stalks which had made some millable cane as early as 9 months was then dead.

The incidence of suckers, first recorded at 12 months in February, continued through May. The record of non-millable suckers at 18 months in August indicates that relatively few new suckers had started after the earlier Spring flush had subsided, but after 18 months another crop of new suckers did get into the population. Actually, the number of suckers carrying millable cane increased rapidly between 12 and 18 months but much more slowly thereafter. The non-millable suckers decreased between 15 and 18 months (apparently becoming millable) but thereafter increased in about the same proportion as the millable suckers did.

None of the primary stalks tasseled in either season, but approximately 20 per cent of the millable suckers had tasseled at 24 months.

Dead suckers, even though they had not tasseled, were found in November at 21 months after planting. (These suckers are actually only about 12 months old at this time.) This sucker mortality amounted to about 15 per cent of the total number of suckers which started out, and in this respect there is similarity with the mortality that had occurred in the primary stalks at 12 months of age.

Between 15 and 24 months, the total number of millable stalks remained quite constant; the primaries were being replaced by the suckers (Fig. 1).

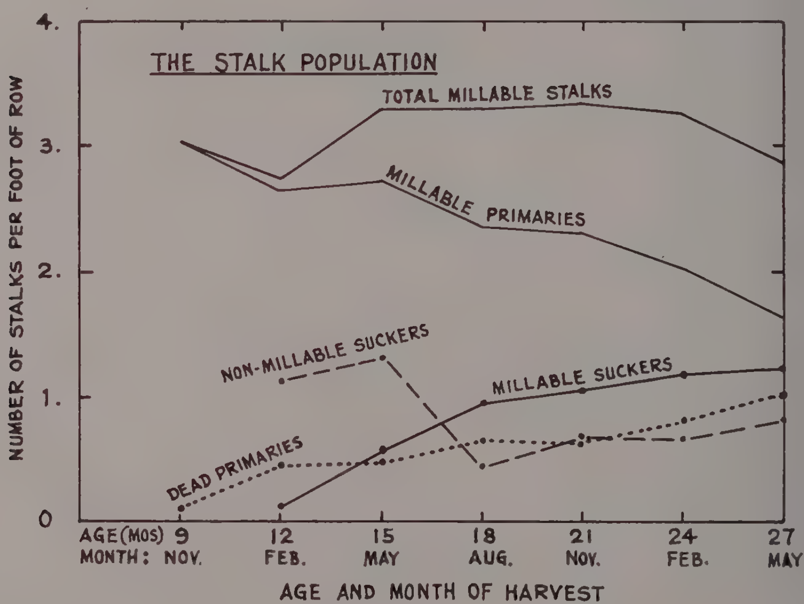

Fig. 1.

The preharvest yields:

The yield data from our experiment are summarized in Table II. Both the millable cane (TCA) and sugar (TSA) weights from the primary stalks increased with age up to 21 months, whereas the suckers continued to produce added tonnages for an additional three months. Hence the total yield of sound millable stalks and their sugar increased up to 24 months. However, the rates of development for both cane (TCAM) and sugar (TSAM) dropped off after 21 months.

Losses in cane and sugar were quite large after 24 months. The amount of dead cane (the difference between TCA for all stalks and for sound stalks only) increased with advancing age, and was a factor that influenced the crusher juices at 18 months and thereafter, especially since the primary stalks were in various stages of dying.

TABLE II

HARVESTING RESULTS

Measurements (averages from 20 stations)	Age and month of harvest: 9 mos. in Nov.	12 mos. in Feb.	15 mos. in May	18 mos. in Aug.	21 mos. in Nov.	24 mos. in Feb.	27 mos. in May
TCA:							
Millable primaries ..	49.9	62.8	77.1	79.9	89.7	85.8	66.0
Millable suckers	0	0.9(1)	10.5	23.5	35.5	46.4	45.7
Sound stalks only...	49.9	63.7	87.6	103.4	125.2	132.2	111.7
All stalks*	49.9	64.9	89.5	107.7	134.3	148.4	133.5
Purity:							
Millable primaries ..	69.3	78.8	82.2	82.1	83.2	84.0	85.3
Millable suckers	.....	48.1(2)	39.4	70.1	81.6	83.3	81.2
Sound stalks only...	69.3	78.7	80.6	80.4	83.4	83.6	82.9
All stalks	69.3	78.8	80.6	79.9	82.2	81.0	79.1
Y%C:							
Millable primaries ..	5.42	8.56	10.52	10.19	10.83	10.76	10.85
Millable suckers	.....	2.86(2)	2.07	6.31	10.00	10.83	9.79
Sound stalks only...	5.42	8.47	9.44	9.50	10.65	10.84	10.53
All stalks	5.42	8.47	9.35	9.22	10.18	9.98	9.11
TSA:							
Millable primaries ..	2.73	5.41	7.85	8.14	9.71	9.23	7.16
Millable suckers	.....	.02(2)	.40	1.68	3.65	5.07	4.64
Sound stalks only...	2.73	5.43	8.25	9.82	13.36	14.30	11.80
All stalks	2.73	5.53	8.35	9.98	13.74	14.85	12.26
All stalks:							
T.C.A.M.	5.5	5.4	6.0	6.0	6.4	6.2	4.9
T.S.A.M.	.30	.46	.56	.56	.65	.62	.45

(1) Only 9 samples. (2) Only 8 samples.

* *Note:* The weight of the dead cane which was included with "*All*" stalks does not give us the actual tonnage of millable cane which had been made and lost, since many of the dead canes were more or less completely dried out when weighed.

The sound cane stalks showed improvement in their juice purities up to 21 months and retained their high level fairly well during the next six months; but in the case where all canes were milled together the purities fell off after 21 months. Apparently the dead canes had a progressively adverse influence for we note losses of 1.2, 2.6, and 4.4 points in purity being recorded for each three-month period thereafter.

The trends in the Y%C figures are quite comparable with those for juice purity. The high point for all sound stalks was reached at 24 months although this was not unlike that found at 21 months in November or at 27 months in May. When all stalks were concerned, the best Y%C occurred in November at the age of 21 months; this was a rather unexpected result for we do not usually find that a crop of sugar cane reaches its best quality in the month of November.

The ratios between the green-leaf and dry-leaf sections of the sound stalks, both for stalk lengths and of cane weights, that were harvested provide further information about this crop. For instance: the ratios of the green-leaf to the dry-leaf sections of the primary stalks decreased at each successive harvest; this is apparently an age effect. The ratios that were found from the suckers at 21 months were not unlike those found in the primaries some 9 months earlier (at 12 months). The suckers had higher ratios of green-leaf to dry-leaf cane at every harvest and al-

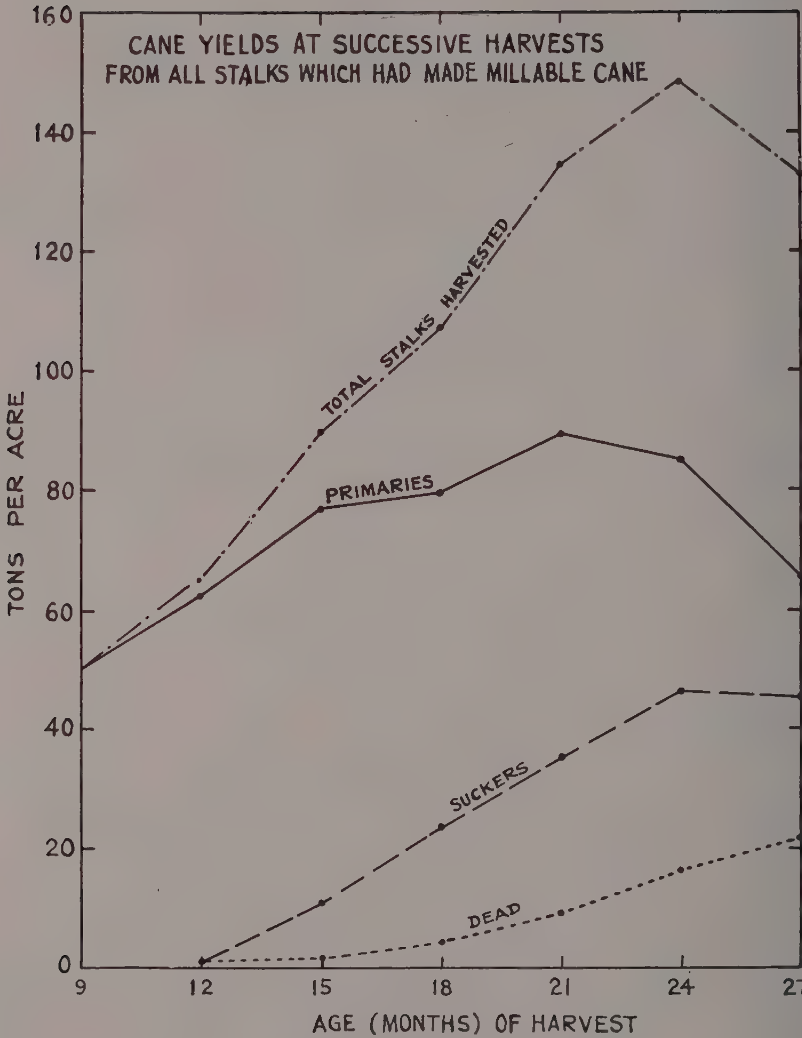

Fig. 2.

though they too showed a decrease between 15 and 24 months, the fact that this decrease did not continue through 27 months suggests that another group of younger age suckers had then been added to the millable stalk population.

(Averages from 20 samples)	Green-leaf : Dry-leaf ratios At 12 mos.	At 15 mos.	At 18 mos.	At 21 mos.	At 24 mos.	At 27 mos.
1. *Stalk length:*						
Primaries	.36	.25	.17	.16	.12	.08
Suckers	.77(1)	1.47	.55	.35	.21	.22
2. *T.C.A.:*						
Primaries	.28	.22	.14	.12	.08	.06
Suckers	.87(1)	.99	.36	.23	.15	.16

(1) Only 9 samples.

Crusher juice analyses:

Both sound primary stalks and suckers were separated into their dry-leaf and green-leaf sections for studies of crusher juice qualities; the Brix and pol analyses and purity calculations are summarized in Table III and shown graphically in Fig. 3.

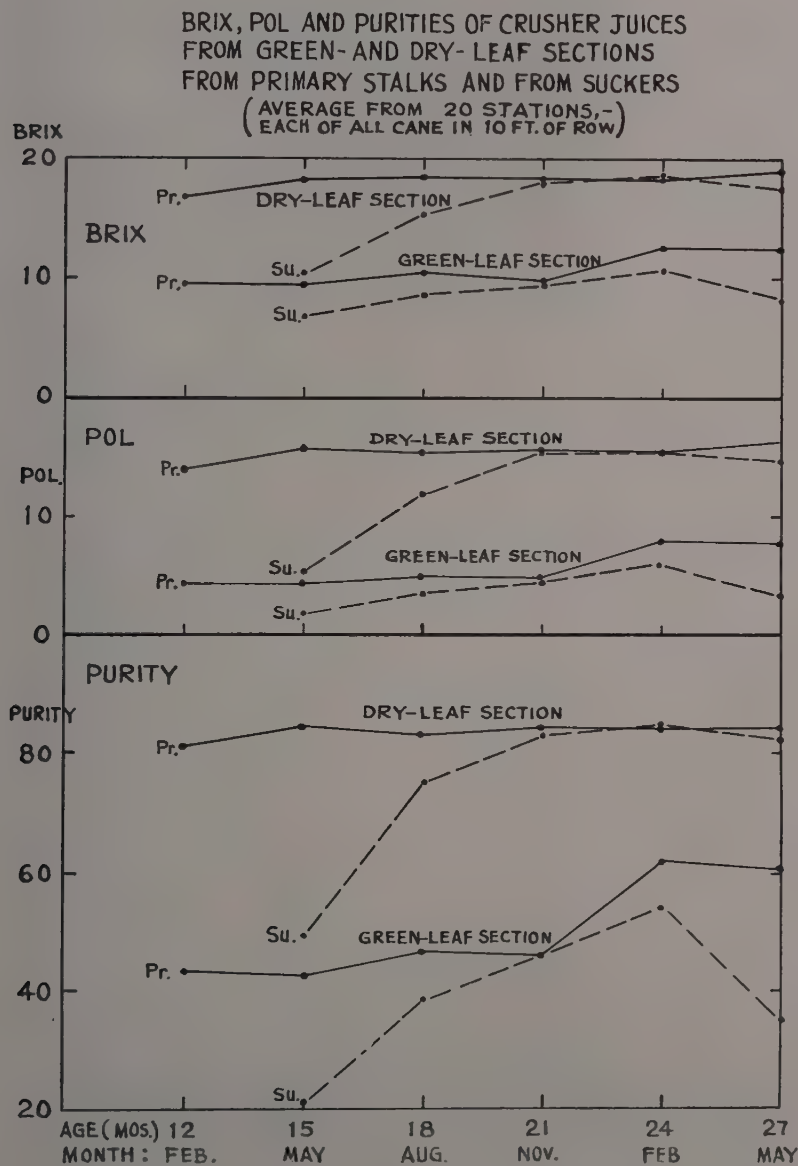

Fig. 3.

TABLE III

THE CRUSHER JUICE ANALYSES OF SOUND CANES ONLY

Stalk section (Averages from 20 samples)	Stalk order	Age and month of harvest 12 mos.	15 mos.	18 mos.	21 mos.	24 mos.	27 mos.
1. *Brix:*							
Dry-leaf	Primaries	16.9	18.5	18.5	18.2	18.4	19.0
Dry-leaf	Suckers	10.6(1)	10.1	15.3	18.0	18.5	17.7
Green-leaf	Primaries	9.5	9.4	10.3	9.8	12.6	12.5
Green-leaf	Suckers	9.0(1)	6.9	8.7	9.4	10.7	8.3
All sound stalks		15.5	16.5	16.9	18.1	17.8	17.6
2. *Pol:*							
Dry-leaf	Primaries	13.7	15.7	15.4	15.3	15.5	16.2
Dry-leaf	Suckers	6.0(1)	5.0	11.8	15.1	15.6	14.6
Green-leaf	Primaries	4.2	4.1	4.9	4.5	7.9	7.7
Green-leaf	Suckers	3.8(1)	1.6	3.4	4.4	5.9	3.1
All sound stalks		12.2	12.3	13.6	15.2	14.9	14.6
3. *Purity:*							
Dry-leaf	Primaries	81.3	84.9	83.4	84.2	84.2	84.9
Dry-leaf	Suckers	44.8(1)	49.4	75.6	83.6	84.3	82.5
Green-leaf	Primaries	43.7	42.7	46.6	46.1	62.1	60.9
Green-leaf	Suckers	37.8(1)	21.4	38.3	46.1	54.8	35.9
All sound stalks		78.7	80.6	80.4	83.4	83.6	82.9

(1) Only 8 samples.

An inspection of these data shows that the Brix, pol, and purity of the dry-leaf sections of the sound primary stalks were apparently fairly well established by 12 months and changed very little thereafter. Furthermore, up until the time when the growth of the primaries was slowed up by the weather of the second winter (*i.e.*, after 21 months in November), a fairly constant level for these juice measurements had also been maintained in the green-leaf sections of the primaries. Thereafter an improvement in these juices from the green-leaf primaries followed the check in stalk elongation that was apparently first brought about by the winter weather and then continued as the field was being dried-off for its final harvest at 27 months.

With the suckers, however, the story is quite different. As we pointed out previously, the first crop of suckers with any considerable amount of millable cane got into the crop at 15 months (only 8 out of the 20 harvesting zones had millable suckers at 12 months). When we look at the data from the sound millable suckers we note a rapid improvement in the Brix, pol, and purity for their dry-leaf sections which brought their levels up to those of the dry-leaf sections of the primaries at 21 months and paralleled these primary stalks thereafter. To a lesser extent the green-leaf sections of the suckers also improved, and at 21 months also reached the level of the primary green-leaf sections, but the green-leaf sections of the suckers did not show the improvement after 21 months that was found in the primaries. This is most likely because the millable suckers after 21 months were not only made up of those which had started at 9 to 12 months after planting but included a second flush of younger suckers which started sometime after 18 months. When these young suckers were harvested with the crop at 27 months their effect on the juice was a distinctly adverse one. In fact the composition of the green-leaf sections of the suckers at 27 months was not unlike that found at 18 months, which fact also suggests that a larger proportion of a younger group of suckers was involved than was in the crop three months earlier.

Discussion:

When all of these data are assembled, *i.e.,* the stalk census, the estimated yields, and the trends in the crusher juice analyses separately from the mature dry-leaf and the more active green-leaf sections of both sound primary stalks and suckers, we have an array of facts about the actual conditions of our cane crop. Perhaps not all of the measurements we made are necessary, but collectively they do tend to support each other and give greater assurance that our interpretations will be right. In actual practice, perhaps, they need not be started until four to six months prior to the expected optimum age for harvest, and four or five successive monthly samplings should give us the necessary information needed for actually setting the harvest date. Normally, if we are to get all the sugar our crop is potentially able to make from the combined growth factors it has received, it would be a mistake to harvest a crop over 12 months of age before the juice of the suckers reached a concentration comparable with that of the primaries, unless there was a considerable increase occurring in the mortality of the primaries. However, once the composition of the juice of the suckers has reached the level of that of the primaries, further delays in harvesting would need to be questioned and carefully watched, especially since they could easily result in a decreased rate of sugar production (TSAM) from the crop, and even in an actual loss of some of the sugar that had been made available in the field. These facts, therefore, should furnish the basic principles for controlled harvesting of crops of sugar cane.

Life History of a New Parasite of the Black Widow Spider in Hawaii

By C. E. Pemberton and J. S. Rosa

Of the several new insects that appeared in Hawaii during the war not all are pests. One has proved to be especially beneficial—it is an active parasite of the black widow spider. It was first seen on the Experiment Station grounds less than a year ago. The Station entomologists have distributed it to all of the main Islands and it is now well established in several localities. An account is given of its life habits with appropriate illustrations.

On May 18, 1945, the junior author, J. S. Rosa, observed a number of small black parasites emerging from an egg sac of the so-called brown or false black widow spider *Latrodectus geometricus* Koch, which had been picked up by his daughter on the grounds of this Experiment Station and left on his desk. The insect shown in Fig. 11 was immediately recognized as quite different from a parasite (*Baeus californicus* Pierce) introduced into Hawaii from California during August 1939 for control of the black widow spider. Mr. Rosa then visited Lualualei, Oahu, with R. H. Van Zwaluwenburg to collect *Latrodectus* egg sacs in that arid part of the island. There they found the same parasite developing on the eggs of the true black widow spider *Latrodectus mactans* (Fabr.). Later he went to Waianae, Oahu, with F. A. Bianchi and found the same parasite in that region also. It was thus shown to be well established and widely distributed on the island of Oahu.

The positive identity of this parasite is still uncertain, nor is it known how it came to Hawaii. Material was sent to C. F. W. Muesebeck, In Charge, Division of Insect Identification, U. S. Bureau of Entomology and Plant Quarantine, who has stated in a letter to D. T. Fullaway, Territorial Entomologist, that this parasite is also known in Puerto Rico and that it is very close to *Eurytoma arachnovora* Hesse, a South African species described by A. J. Hesse in The Journal of the Entomological Society of Southern Africa, Volume 5, pp. 59–63, September 1942. The identification was made by A. B. Gahan, Senior Entomologist of the U. S. Bureau. We sent material of this parasite to Dr. Hesse who compared it carefully with the African parasite and found it definitely different and is of the opinion that it is not *arachnovora,* although very closely allied. Another species, quite similar to the one in Hawaii or possibly the same, was briefly described by A. A. Girault from material reared from spider egg sacs at Moree, New South Wales, Australia. Girault gave it the name *Bruchophagus* (*Eurytoma*) *arachnophagus* and his description appeared in Insecutor Inscitiae Menstruus, Volume 13, pp. 99–100, April-June 1925. The description was too brief to be used in a comparison of the Hawaiian and Australian species. At present we can only refer to the Hawaiian parasite as a species of *Eurytoma.*

It is believed that one or more *Latrodectus* egg sacs, containing this parasite, reached Hawaii concealed in a motor-car body or in war materials or other freight

brought from some outside country direct to Hawaii and unloaded somewhere on Oahu where either of the two local species of *Latrodectus* was present. The escaping parasites would thus find conditions suitable for establishment. Since this parasite is not known on the mainland of the United States, it probably came to Hawaii from some more distant land. The parasite is undoubtedly a very recent introduction. Quantities of *Latrodectus* egg sacs have been collected on Oahu by Station entomologists since August 1939 without recovery of this parasite prior to May 1945. Its sudden appearance over a wide area of Oahu indicates a strong capacity for spreading and maintaining itself. The fact that it develops on the eggs of both species of *Latrodectus* is an important factor contributing toward its effectiveness in the control of *Latrodectus mactans* the more dangerous of the two spiders.

During June, July, and August 1945, the junior author has reared quantities of this parasite on black widow spider eggs and distributed them to other islands of the Hawaiian group where the spider is known to occur. This work has made possible the accumulation of the data on the habits and life history of the parasite as discussed below.

The female *Eurytoma* forces her short ovipositor through the thin wall of the spider egg sac and places her eggs within the loose silken threads just inside the wall. She is shown in position for ovipositing in Fig. 1. The parasite's eggs are

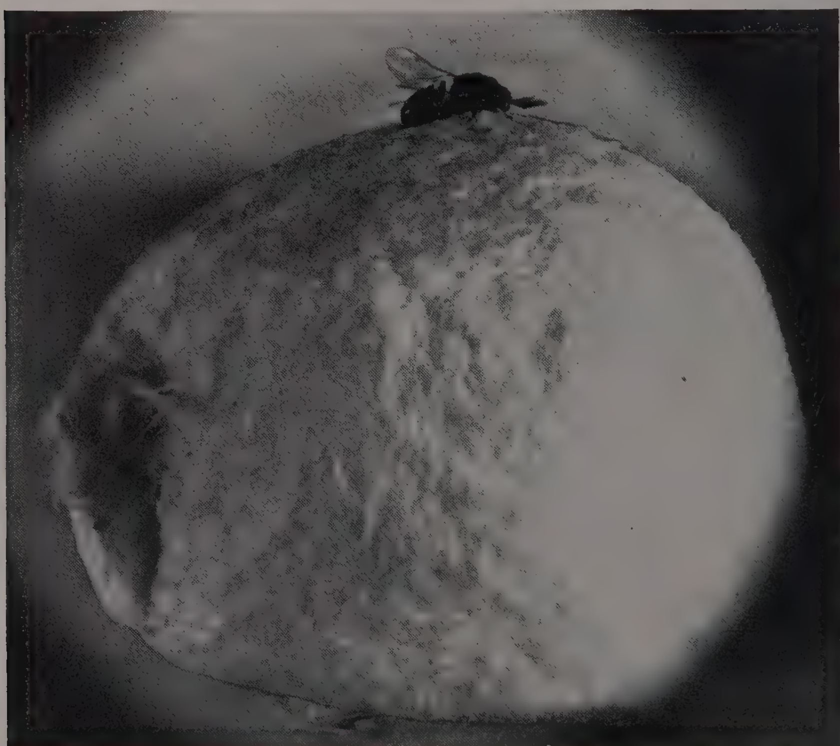

Fig. 1. Parasite ovipositing in spider egg sac.

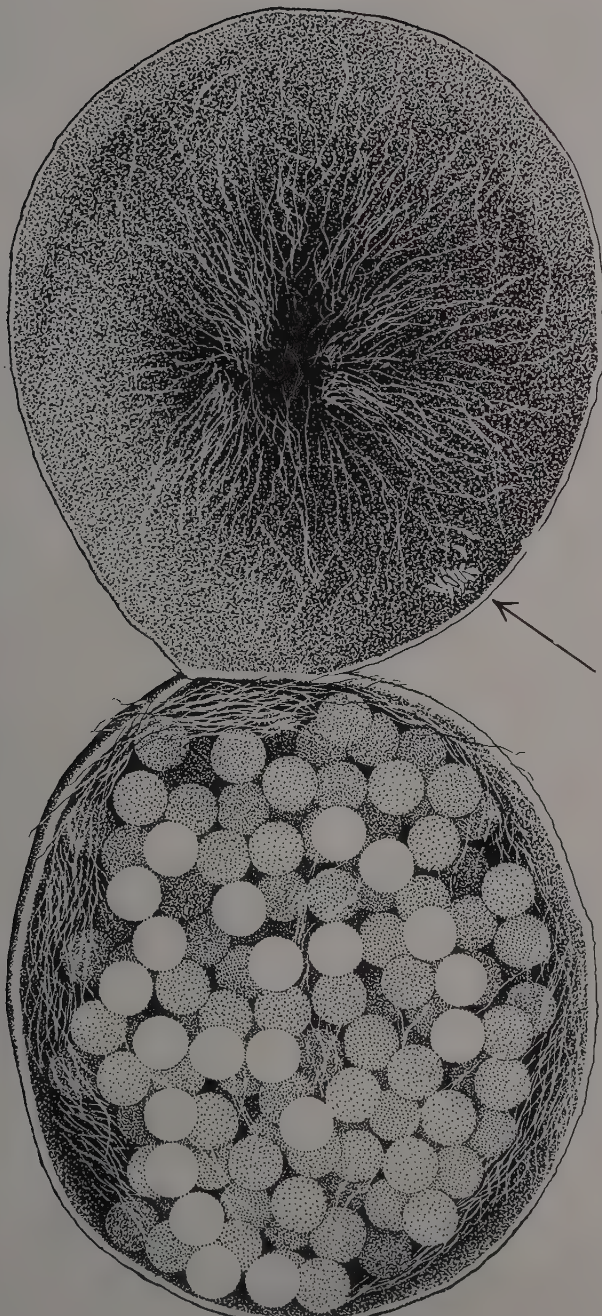

Fig. 2. Spider egg sac opened to show spider eggs and parasite eggs in normal position as indicated by arrow.

shown in Fig. 2, exposed to view by cutting open the spider egg sac. The eggs are laid either singly or in small clusters as shown. The egg is approximately 0.33 mm. long by 0.132 mm. wide at the widest part, pale white, ovoid, smooth and glistening, attenuated at the anterior end into a short stalk about one-sixth the total length of the egg. There is also a short, minute flagellum-like process at the opposite end, only visible under considerable magnification. The newly deposited egg is shown in Fig. 3. Under summer temperatures indoors in Honolulu it was found that the eggs hatched approximately 45 to 48 hours after deposition.

Fig. 3. Newly deposited parasite egg.

The newly hatched larva is somewhat longer than the egg. Measured individuals averaged 0.50 mm. in length. It is shown in Fig. 4. The head and 13 body segments can be distinguished. Four pairs of functional spiracles can be recognized; there being a pair on the 2nd, 3rd, 4th and 5th body segments respectively.

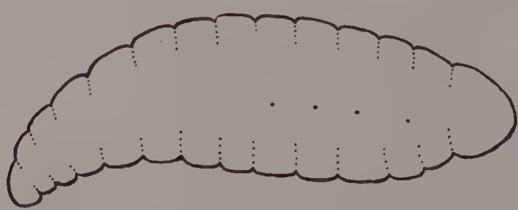

Fig. 4. Freshly hatched larva.

A pair of sharply curved mandibles can be recognized in the head under high magnification. They are faintly chitinized. They are shown, greatly enlarged in Fig. 5. The larva is capable of very sluggish movement which is sufficient to enable it to shift its position to bring its head in contact with a spider egg. The mandibles then pierce the shell of the egg to release slowly the semi-liquid contents, which are rapidly absorbed by the parasitic larva.

Growth is very rapid. Within 48 hours after hatching the larva has doubled in size and has caused about one quarter of the spider egg to collapse on the side where the larva is attached and feeding. By the end of the fourth day after hatching the larva averages 2.8 mm. in length and has consumed the entire contents of at least

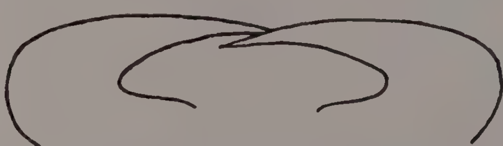

Fig. 5. Mandibles of freshly hatched larva.

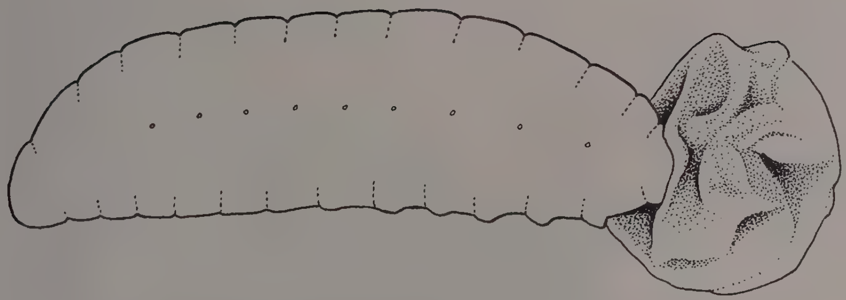

Fig. 6. Half-grown larva completing destruction of spider egg.

one spider egg and by the sixth day is completely developed as a larva and is about 3 mm. long by 1 mm. wide at its greatest width. By this time most of the eggs in a parasitized spider egg sac have been emptied of their contents as shown in Figs. 6 and 7. Early in its growth and apparently after the first moult, of which there

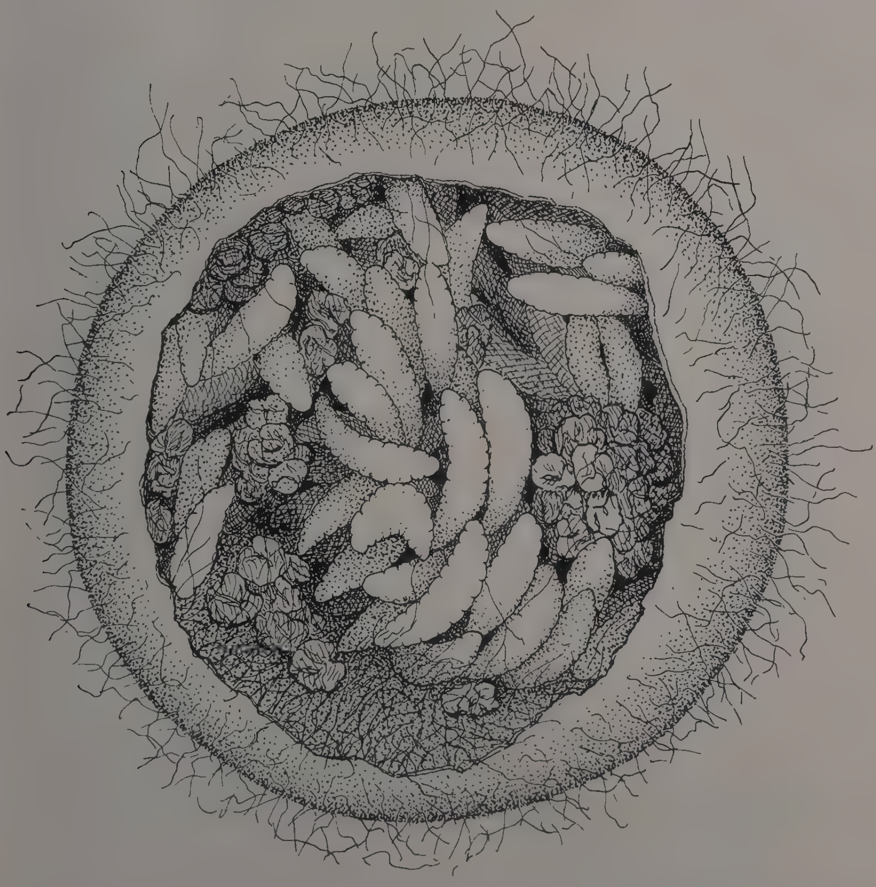

Fig. 7. Opened spider egg sac showing parasite larvae and collapsed spider eggs.

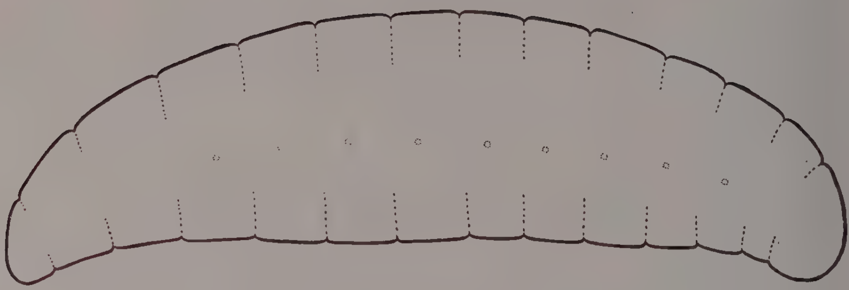

Fig. 8. Mature parasite larva showing number and position of spiracles.

are several, the respiratory system is greatly expanded to include 9 pairs of functional spiracles along the sides of the body to connect internally by short tracheal branches directly to the main pair of large tracheal trunks extending from the second to the tenth body segment inclusive. The position and number of these spiracles are shown in the mature larva illustrated in Fig. 8.

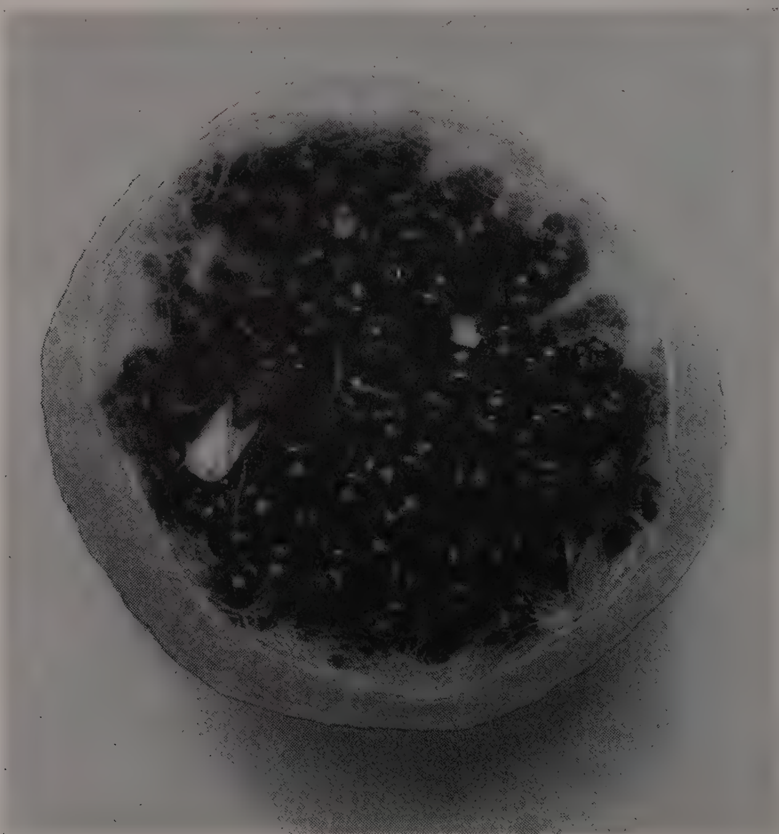

Fig. 9. Opened spider egg sac showing parasite pupae.

By the end of the seventh day after hatching, the larva has completed growth and feeding. It casts the larval meconium (much of the intestinal contents accumulated during growth) and pupates. Many larvae under observation began pupating at the end of the seventh day and all had pupated by the beginning of the eighth day. In each case it was noted that the larva became somewhat reduced in size with the casting of the meconium and the pupa is slightly shorter than the mature larva.

The pupal stage was found to last from 5 to 6 days. During the first day the pupa is pale white. By the second day a black tinge is evident in the integument and by the end of the fourth day it has become jet black as shown in Fig. 9.

Most of the pupae under observation matured to adults on the sixth day after pupation, only 2 to 4 per cent being males. Males appear to hatch at least a few hours before the females and remain within the spider egg sac to mate with the hatching females before they have time to chew their way out of the silken enclosure. Only rarely has mating been observed in glass tubes after the adults have left the egg sac. The parasites certainly remain several hours within the egg sac before emerging entirely from it. On the date of hatching they can be seen moving about within the sac if it is held between the observer and a strong light. The parasites

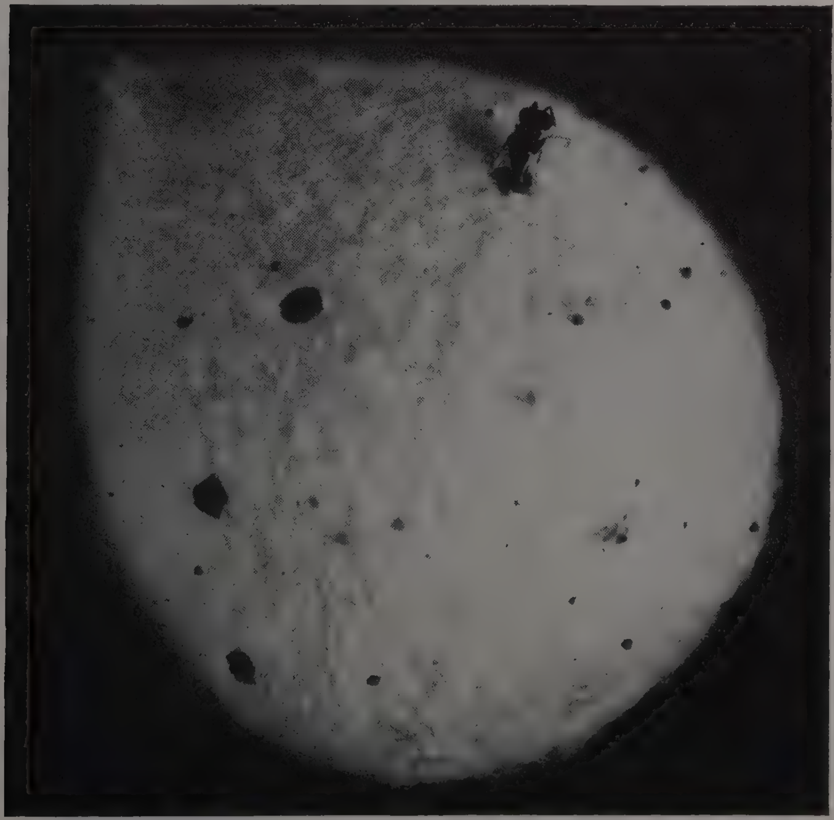

Fig. 10. Spider egg sac showing exit holes made by parasites and one emerging.

finally emerge from the egg sac by biting neat, clean-cut, circular holes through the wall. The holes are usually about ¾ mm. in diameter. Usually from 3 to 5 holes are sufficient to permit the escape of all of the parasites. These holes are readily distinguished from the larger, irregular, ragged holes cut by young spiders when they escape from the egg sac. A parasite emerging from a spider egg sac and some emergence holes already made can be seen in Fig. 10.

The parasite does not begin ovipositing until it is at least three days old. The ovaries of newly hatched females contain no well-developed eggs; but many eggs are well developed a few days later. When a week old as many as 53 mature eggs have been dissected from a female that has had no opportunity to oviposit. Normally, oviposition seems to be completed within the first two weeks after hatching, if spider egg sacs are available. Individuals have been kept alive in glass tubes for several weeks without difficulty; the longest life span of a single female being 38 days.

The number of parasites reared from single spider egg sacs has varied from 25 or less to 286; the average usually being under 100. Where an excessive number of parasite eggs has been placed in a single spider egg sac, the resulting parasite larvae are much undersized through overcrowding and semi-starvation and the resulting parasites which emerge are often less than one-half normal size. Since the larvae are able to move slowly about within the egg sac, each larva does not necessarily confine its feeding to a single spider egg. As a result the percentage of spider egg destruction in any given egg sac which has been parasitized is usually 100 per cent. Rarely do any spiders hatch from parasitized egg sacs.

Fig. 11. Adult parasite.

The time elapsing from the deposition of the *Eurytoma* egg into the spider egg sac until the resulting parasite cuts its way out has been observed by the junior author on several thousand individuals. This has averaged 16 days, with a minimum of 15 days and a maximum of 18 days, which was very uncommon. At least under summer temperatures in Honolulu there has been no indication that this parasite produces any progeny that undergo a period of quiescence or suspended development to tide the species over during periods of spider scarcity. With the preoviposition period of the female covering from 3 to 4 days, the total life cycle for this

species during the summer indoors in Honolulu thus averages about 19 days, with but little variation.

In view of the habits of this parasite, it is believed that it will prove of permanent value in Hawaii in the control of the poisonous black widow spider *Latrodectus mactans* and its close cousin *Latrodectus geometricus* or any other spiders of the same genus which may reach Hawaii in the future.

Variety Differences in Nitrogen Utilization*

By R. J. Borden

An opinion that some cane varieties can make more efficient use of their total nitrogen supplies than others is strengthened by the results from a study which has shown that different varieties have been differentially affected in many of their characteristics by altering their supplies of available nitrogen. Especially important is the information that our present major variety, 32-8560, has made more sugar from less nitrogen than one of the canes it has replaced, H 109, and also that there is an indication that a too-liberal supply of nitrogen for 32-8560 may not be desirable.

From the results of field experiments in which the objective has been to find the optimum amount of nitrogen fertilizer to apply for high sugar yields from 32–8560 cane, there has been considerable evidence to suggest that this cane variety does not need to be supplied with as much nitrogen fertilizer as some of the varieties it has replaced. For instance, although we had frequently obtained a favorable response from H 109 cane to nitrogen applications considerably above 150 pounds per acre, the experiments with 32–8560 on the same soils seldom showed significant gains in sugar yield for amounts above this figure. Two reasons were suggested as the possible causes of this difference: (1) that 32–8560 was a deeper and more extensively rooted variety and was thus able to draw more liberally from the soil's nitrogen supply, and (2) that this variety was actually a more efficient user of the nitrogen which it absorbed.

The present study was planned to check the relative efficiency in nitrogen utilization by 32–8560 and H 109; and a newer variety 35–1515 which was attracting attention was also included. By growing these three varieties in standard-sized pots, filled with identical amounts of well-mixed soil, we have eliminated differences in the extent and content of their root-feeding zones, and thus provided conditions which make it possible to study the relative efficiency in their utilization of specific supplies of available nitrogen.

Cuttings of the three varieties were planted late in March 1944 in pots of a Manoa soil which contained 80 p.p.m. of readily available nitrogen (.32 gm. N per pot) and which was adequately fertilized with phosphate and potash. Nitrogen differentials were imposed to provide four different levels of nitrogen applied as follows:

	Grams N per pot applied				
Nitrogen level	At planting	At 3 mos.	At 5 mos.	At 7 mos.	Total
Very low	2.2	0	0	0	2.2
Low	2.2	2.2	0	0	4.4
Average	2.2	2.2	2.2	0	6.6
High	2.2	2.2	2.2	2.2	8.8

* Project A-105—No. 161.1.

With the .32 gram of readily available nitrogen in the soil of each pot at planting, the known total available nitrogen supply for these four nitrogen levels was 2.52, 4.72, 6.92, and 9.12 grams progressively.

Six replicates of each nitrogen treatment for each variety were provided, and all pots were provided with drainage pans so that all leachates could be returned and there would be no nitrogen losses through leaching.

The plants were grown under glass cover for 4 months and then moved outside. The crop was harvested at the age of 12 months. Millable stalks were more than 90 per cent primary stalks and there were only a few very short stalks of secondary origin. No secondary stalks made millable cane except (1) the H 109 and 35–1515 grown at the high nitrogen level, and (2) the 32–8560 grown at both the average and high nitrogen levels. Secondary stalks which started and failed to make more than three internodes were collected as part of the trash.

Tasseled stalks were found only in the two lower nitrogen levels; they amounted to 25 per cent of the H 109 and to 12½ per cent of the 32–8560 canes grown at these deficient nitrogen levels. No stalks of 35–1515 tasseled but all of this variety grown at the lowest nitrogen level produced noticeably pithy stalks.

The complete data have been summarized in short 3 by 4 factorial tables for ease in comparisons. The figures in the body of these tables are averages from 6 replicates; the variety averages are from 24 pots (6 at each of the 4 levels of nitrogen). All data have been studied by analysis of variance and the significance of differences found for both of the main effects (varieties and nitrogen levels) and for their interactions. Thus all definite statements made without reservation or qualifications in the discussion which follows can be supported by statistical significance.

Millable Cane Stalks

The cane stalks were cut off at ground level and topped at their growing points; no dry trash, green-leaf blades or sheaths were included with the stalk samples.

Green Weights:

In green weight of millable cane, the three varieties ranked in the following order: H 109, 32–8560, 35–1515. However, there was a variation in this order at the lower nitrogen levels, *e.g.*, 32–8560 produced more cane than H 109 at the very low level and was equal to H 109 at the low level.

GREEN WEIGHT (GRAMS) OF MILLABLE STALKS

	Nitrogen level				
Variety	V-low	Low	Average	High	Variety average
H 109	2034	2695	3136	3327	2798
32–8560	2274	2651	2926	2870	2680
35–1515	1753	2254	2474	2738	2305

All weights increased as the nitrogen levels were raised.

Per Cent Moisture:

There was no evidence of an interaction between the varieties and their nitrogen applications; the H 109 cane had a significantly higher percentage of moisture at

all nitrogen levels. The other two varieties were quite similar in their moisture content.

PER CENT MOISTURE IN GREEN WEIGHT OF STALKS

Variety	Nitrogen level				Variety average
	V-low	Low	Average	High	
H 109	69.6	71.2	71.9	71.6	71.1
32–8560	67.1	67.9	69.0	69.1	68.3
35–1515	67.5	68.1	69.1	69.6	68.6

Increasing the nitrogen resulted in higher concentrations of moisture in all varieties; the gains were highly significant when the very low and low levels of nitrogen were increased.

Dry Weight:

In dry weight of cane stalk, 32–8560 exceeded H 109 except at the high nitrogen level. For some unknown reason the high nitrogen application failed to raise the dry weight of 32–8560 above the average application and in this respect 32–8560 differed from the other two varieties. The 35–1515 produced significantly less dry weight of stalk at all four nitrogen levels.

DRY WEIGHT (GRAMS) OF MILLABLE STALKS

Variety	Nitrogen level				Variety average
	V-low	Low	Average	High	
H 109	617	777	879	942	804
32–8560	747	850	908	888	848
35–1515	570	718	763	831	721

Extraction of Juice:

Juice extraction by a small power-driven 3-roller mill showed variety differences which were not, however, influenced by the different nitrogen applications. The extraction from H 109 was significantly higher than from 32–8560 and both of these canes released much larger amounts of juice under similar pressure than was secured from the 35–1515. Until the moisture figures were obtained, these differences in juice extraction were thought to be the effects from different percentages of moisture in the stalks, but apparently there is some other factor concerned, for although 32–8560 and 35–1515 had a similar moisture content, they differed widely in their per cent juice extraction.

JUICE EXTRACTIONS—PER CENT OF MILLABLE CANE WEIGHT

Variety	Nitrogen level				Variety average
	V-low	Low	Average	High	
H 109	33.7	31.6	29.9	30.4	31.4
32–8560	29.9	29.3	28.8	28.9	29.2
35–1515	17.1	17.1	18.1	19.1	17.9

Per Cent Nitrogen in Juice:

The concentration of nitrogen in the juice obtained from the small mill extraction was significantly higher in 32–8560 than in 35–1515 grown at the two higher nitrogen levels but not at the two lower levels. Both of these canes had a definitely higher per cent N in juice than H 109.

PER CENT NITROGEN IN CRUSHER JUICE

Variety	Nitrogen level V-low	Low	Average	High	Variety average
H 109	.005	.009	.017	.028	.015
32–8560	.008	.022	.047	.073	.038
35–1515	.010	.021	.038	.064	.033

Increasing the nitrogen applications resulted in increased concentrations of nitrogen in the crusher juices.

Brix and Pol of Crusher Juices:

Without exception, at comparable nitrogen levels, 32–8560 had the highest Brix and pol in its crusher juice and the 35–1515 juices were higher than those from H 109.

BRIX AND POL OF CRUSHER JUICES

	Nitrogen level									
	V-low		Low		Average		High		Variety avg.	
Variety	Brix	Pol	Brix	Pol	Brix	Pol	Brix	Pol	Brix	Pol
H 109	21.4	20.3	19.5	18.6	18.8	17.6	18.8	17.7	19.6	18.5
32–8560	24.4	23.2	23.7	22.4	23.6	21.9	23.1	21.3	23.7	22.2
35–1515	23.1	22.1	21.9	20.4	21.6	20.1	21.4	19.7	22.0	20.6

The increased nitrogen applications have resulted in a lower Brix and pol.

Crusher Juice Purity:

With respect to juice purity there are some inconsistencies in the variety comparisons. At the very low nitrogen level the purities were quite similar and at the average level the differences in purity are also easily within the range of experimental error. But at the low nitrogen level, H 109 had a significantly higher purity than 35–1515, and from the high application H 109 was superior to both 35–1515 and 32–8560.

JUICE PURITIES

Variety	Nitrogen level V-low	Low	Average	High	Variety average
H 109	94.5	95.0	93.4	94.4	94.3
32–8560	95.0	94.4	93.1	92.2	93.7
35–1515	94.9	93.1	92.9	91.9	93.2

The deleterious effect of increases in nitrogen upon juice purities was quite definite with 32–8560 and 35–1515 but was not proved with H 109.

Yield Per Cent Cane:

No interaction between variety and nitrogen effects was measured in yield per cent cane. The 32–8560 cane had a significantly higher yield of sugar per 100 pounds of cane than the 35–1515, and the 35–1515 had a significantly higher yield than the H 109.

YIELD PER CENT CANE

Variety	Nitrogen level V-low	Low	Average	High	Variety average
H 109	15.9	14.6	13.7	13.9	14.5
32–8560	18.2*	17.5	17.0	16.5	17.3
35–1515	17.3	15.8	15.6	15.1	15.9

* As a matter of record these Y%C figures calculated from the Brix and pol of juice from this cane are the highest we have recorded for any canes crushed in our 3-roller mill for more than 10 years.

The increased nitrogen applications were responsible for a poorer cane quality.

Recoverable Sugar:

Largely due to its higher Brix and pol and a better cane quality, 32–8560 has produced more sugar than the other two canes from the three lower nitrogen applications, but at the high level, its recoverable sugar yield fell off and was equalled by H 109. Two effects are probably involved in this difference: (1) the 32–8560 failed to respond in its cane yield to the high over the average application of nitrogen, whereas H 109 did increase its cane yield, and (2) the high nitrogen level had an adverse effect on the quality of 32–8560 but did not similarly affect H 109. At the very low nitrogen level, sugar yields from 35–1515 and H 109 were not significantly different but as the nitrogen was increased, H 109 then outyielded 35–1515.

POUNDS OF RECOVERABLE SUGAR

Variety	Nitrogen level				Variety average
	V-low	Low	Average	High	
H 109	.71	.87	.95	1.04	.89
32–8560	.91	1.02	1.10	1.04	1.02
35–1515	.67	.78	.85	.91	.80

Total Nitrogen:

In the millable stalks of these cane varieties at their harvest at 12 months after planting, we find 32–8560 stalks with greater actual amounts of nitrogen than the other two canes, especially from the two higher levels of nitrogen; 35–1515 and H 109 do not show significant differences in this characteristic.

TOTAL GRAMS OF NITROGEN IN MILLABLE STALKS

Variety	Nitrogen level				Variety average
	V-low	Low	Average	High	
H 109	.627	1.238	1.851	2.925	1.660
32–8560	.687	1.464	2.603	3.520	2.069
35–1515	.530	1.258	2.091	2.847	1.682

Greater actual amounts of nitrogen were found to follow the increased nitrogen applications.

Tops and Trash

All leaves which matured while these crops were growing were collected and dried, and at the time of harvest, all tops or green leaves were also obtained and dried. The total dry weights of tops and trash were combined for each replicate and samples were analyzed for their total nitrogen content.

Dry Weight:

In general, H 109 produced a heavier amount of tops and trash than 35–1515, and 35–1515 likewise a greater amount than 32–8560 except at the lowest nitrogen level. The differences were all highly significant at the higher levels of nitrogen which these canes had received.

DRY WEIGHT (GRAMS) OF TRASH AND TOPS

Variety	Nitrogen level				Variety average
	V-low	Low	Average	High	
H 109	390	519	599	649	539
32–8560	370	461	493	495	455
35–1515	351	488	576	608	506

Each successive increment of nitrogen increased the weight of trash and tops from H 109 and 35–1515, but here again 32–8560 did not increase its top weight when more than the average nitrogen application was given.

Per Cent Nitrogen in Trash and Tops:

The percentage of nitrogen in the trash and tops of H 109 was higher than the other varieties at all nitrogen levels. But a variety-nitrogen interaction influenced the concentration of nitrogen in 32–8560 and 35–1515, *e.g.,* at the two lower nitrogen levels, the per cent N was higher in trash and tops from 32–8560 than from 35–1515, whereas this concentration was just the reverse at the two higher nitrogen levels.

PER CENT NITROGEN IN TRASH AND TOPS

Variety	Nitrogen level				Variety average
	V-low	Low	Average	High	
H 109	.322	.372	.443	.463	.400
32–8560	.289	.359	.379	.409	.359
35–1515	.263	.333	.399	.441	.359

The concentration of nitrogen in the tops and trash was increased with increased nitrogen applications.

Total Nitrogen:

H 109 actually picked up the greatest amounts of nitrogen in its tops and trash, and at the two higher nitrogen levels 35–1515 had more than 32–8560. Apparently there is a good positive relation between dry weight of tops and trash and per cent nitrogen in this dry weight.

TOTAL GRAMS OF NITROGEN IN TRASH AND TOPS

Variety	Nitrogen level				Variety average
	V-low	Low	Average	High	
H 109	1.257	1.930	2.656	3.007	2.213
32–8560	1.067	1.656	1.864	2.029	1.654
35–1515	.921	1.621	2.297	2.675	1.878

The total amounts of nitrogen found in the trash and tops have reflected the total amounts of nitrogen which were supplied.

Roots and Stubble

All cane stubble left below ground level at harvest, and all roots which could be collected from the soil by screening and quick flotation were combined for study of the amounts and nitrogen content of this "below-ground" crop.

Dry Weights:

The variety 35–1515 produced a greater dry weight of roots and stubble than H 109 at all nitrogen levels. At the high nitrogen level, 35–1515 also definitely exceeded 32–8560, and its superior weight is also indicated at lesser nitrogen levels. The dry weight of roots and stubble from 32–8560 exceeded that from H 109 and was significantly greater at the low level.

DRY WEIGHT (GRAMS) OF ROOTS AND STUBBLE

Variety	Nitrogen level V-low	Low	Average	High	Variety average
H 109	107	113	166	170	139
32–8560	130	149	175	191	161
35–1515	135	179	185	243	186

As was the case with the "above-ground" parts (stalks and tops and trash) there have been increases in the dry weights of the roots and stubble which have followed the increased applications of nitrogen.

Per Cent Nitrogen in Roots and Stubble:

With the exception of the very low nitrogen applications, in which case the three varieties had a similar concentration of nitrogen in their roots and stubble, H 109 had a significantly greater per cent N in these "below-ground" parts of its crop than either 32–8560 or 35–1515; these two latter varieties did not differ in this measurement.

PER CENT NITROGEN IN ROOTS AND STUBBLE

Variety	Nitrogen level V-low	Low	Average	High	Variety average
H 109	.451	.681	.841	.906	.720
32–8560	.433	.560	.649	.719	.590
35–1515	.458	.537	.633	.723	.588

The concentration of nitrogen in the roots and stubble was positively influenced by the nitrogen applications.

Total Nitrogen:

The total amount of nitrogen found in the roots and stubble, although dominated greatly by the amounts supplied, shows some inconsistent differences between the varieties at the different nitrogen levels. Thus, at the very low and also at the low level, 35–1515 had more nitrogen than H 109 but not significantly more than 32–8560; H 109 and 32–8560 had quite similar amounts. At the average nitrogen level, H 109 had significantly more nitrogen than either 35–1515 or 32–8560, which in turn were very similar. From the high nitrogen application, 35–1515 once again had more nitrogen than H109, while H 109 still had more than 32–8560. These differences are difficult to rationalize but are recorded to keep the data complete.

TOTAL GRAMS OF NITROGEN IN ROOTS AND STUBBLE

Variety	Nitrogen level V-low	Low	Average	High	Variety average
H 109	.478	.758	1.393	1.532	1.040
32–8560	.560	.835	1.132	1.366	.973
35–1515	.615	.959	1.168	1.739	1.120

Recoveries of total nitrogen in roots and stubble were positively correlated to the amounts of nitrogen supplied.

Entire Crop

The total dry weights for the entire crop and its total nitrogen have been found by summing the figures found separately for the millable cane, tops and

trash, and roots and stubble. They are interesting because they show the combined influences of the separate components of the three cane varieties that we have discussed.

Total Dry Weights:

The variety 32–8560 has produced the greatest total amount of dry matter from the very low application of nitrogen; hence its greater nitrogen efficiency or ability to produce more dry weight per unit of available nitrogen is quite nicely indicated. At both the low and the average nitrogen levels the differences between the varieties were not proved significant. But from the highest application of nitrogen, there has undoubtedly been a depressing effect on the total dry weight obtained from 32–8560, and we find H 109 making definitely more total organic material than 32–8560 (but not significantly more than 35–1515) at this high nitrogen level.

DRY WEIGHT (GRAMS) OF ENTIRE CROP

	Nitrogen level				
Variety	V-low	Low	Average	High	Variety average
H 109	1114	1410	1644	1761	1482
32–8560	1246	1459	1576	1574	1464
35–1515	1056	1385	1523	1682	1412

Total Nitrogen:

At the two lowest nitrogen levels, H 109 and 32–8560 have recovered fairly comparable amounts of nitrogen and both slightly more than 35–1515 was able to obtain. At the average nitrogen level, 32–8560 and 35–1515 have taken up quite similar amounts while H 109 has been able to recover a significantly greater amount than either of the others. 32–8560 has fallen below the other two varieties in its nitrogen recovery from the highest application.

TOTAL GRAMS OF NITROGEN RECOVERED IN ENTIRE CROP AND PERCENTAGE RECOVERY FROM TOTAL AVAILABLE NITROGEN*

	Nitrogen level									
	V-low		Low		Average		High		Variety avg.	
Variety	Gms.	%	Gms.	%	Gms.	%	Gms.	%	Gms.	%
H 109	2.362	93.7	3.925	83.2	5.899	85.3	7.464	81.9	4.913	86.0
32–8560	2.314	91.8	3.956	83.8	5.598	80.9	6.915	75.8	4.696	83.1
35–1515	2.066	82.0	3.838	81.3	5.556	80.3	7.262	79.6	4.681	80.8

* Includes 0.32 gram water-soluble N in soil at potting plus amounts added in fertilizer.

Although the total amounts recovered bear a direct relationship to the amounts of nitrogen applied, the percentage recoveries from the available nitrogen supplies indicate an inverse relationship. Soil analyses after harvest showed that less than .008 gram of available nitrogen remained from the very low nitrogen applications, between .008 and .016 gram remained in the soil from the low and the average nitrogen applications, and between .012 and .016 gram of N in the soil fertilized to maintain the high nitrogen level; these residual amounts are inadequate to account for the aforementioned differences in the percentage recoveries of nitrogen that was available.

Distribution of Total Nitrogen

In Fig. 1 the distribution of the total nitrogen found in the crops of each variety is graphed to show how these varieties have differed in their placement of the nitrogen they took up. In the H 109 crop the greater part of the nitrogen was always found in the tops and trash, and this was also true for 35–1515 except when this cane received the high nitrogen application. But 32–8560 when it received average or high nitrogen fertilization placed considerably less of its total nitrogen in its tops and trash than in its millable cane.

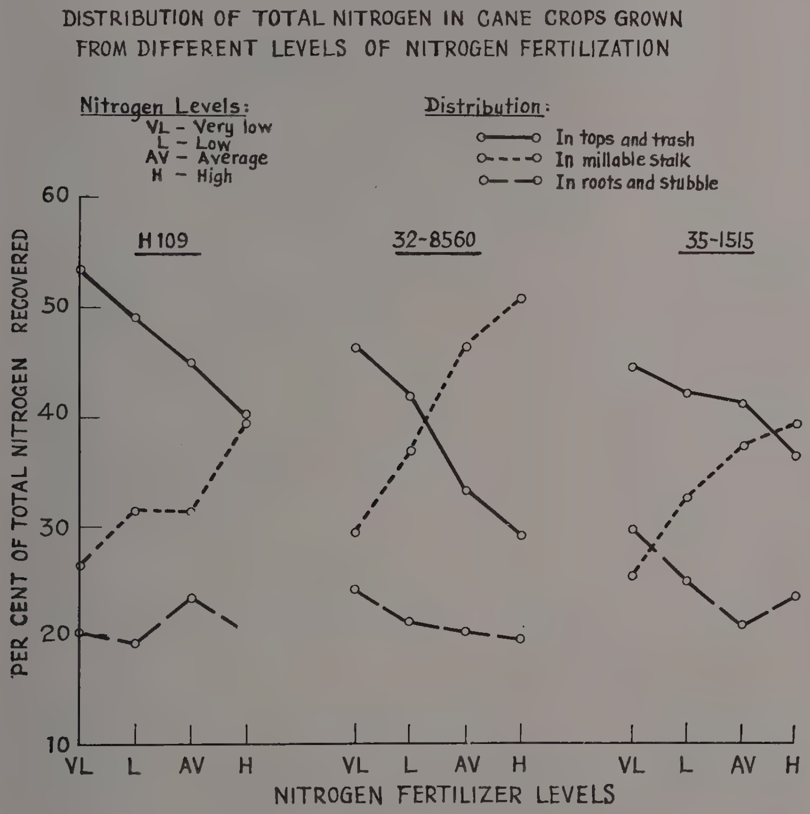

Fig. 1

At similar nitrogen levels H 109 always carried a greater percentage of its total nitrogen in its trash and tops than the other varieties did. Conversely 32–8560 placed more of its total nitrogen in its millable stalks than either H 109 or 35–1515, and apparently 35–1515 has stored a greater proportion of nitrogen below ground level than either 32–8560 or H 109.

Segregation of Total Dry Weight

On a dry weight basis there are some variety differences in the proportions of the total dry weight found in the three parts of the crops which were separately

collected. Apparently 32–8560 has the greater percentage of its total dry weight in its stalks, and has put the smallest amount in trash and tops. The variety 35–1515 has a higher proportion of its dry weight in its roots and stubble than either H 109 or 32–8560. The differences in these proportions which resulted from growing the canes at the several nitrogen levels were not significant.

PERCENTAGE OF TOTAL DRY WEIGHT

Found as	Variety			Nitrogen level				Approx. average
	H 109	32–8560	35–1515	V-low	Low	Avg.	High	
Millable stalks	54	58	51	57	55	54	53	55
Tops and trash........	37	31	36	32	35	35	35	34
Roots and stubble.....	9	11	13	11	10	11	12	11

A study of the principal ratios of dry weights from the crop segregation also shows variety influences which are somewhat more significant than nitrogen fertilizer effects. 35–1515 has a somewhat higher ratio of "below ground" parts (roots and stubble) to "above-ground" parts (tops, trash, and stalks) than the other varieties. Both 35–1515 and 32–8560 have higher ratios of roots and stubble to tops and trash than H 109. Both H 109 and 32–8560 have lower ratios of roots and stubble to stalks than 35–1515 has. The 32–8560 had the lowest ratio of tops and trash to stalks, and also the lowest amount of all non-stalk materials produced.

Increases in the amounts of nitrogen applied resulted in increased ratios of roots and stubble to stalk, tops and trash to stalks, and tops, trash, roots and stubble to stalks. Apparently millable stalk formation did not keep up with the production of the non-millable parts which were stimulated by the additions of nitrogen.

COMPARATIVE RATIOS

The ratio of	Variety			Nitrogen level				Approx. average
	H 109	32–8560	35–1515	V-low	Low	Avg.	High	
Roots and stubble to tops, trash and stalks........	.10	.12	.15	.12	.12	.12	.14	.13
Roots and stubble to tops and trash	.26	.36	.37	.34	.30	.32	.35	.33
Roots and stubble to stalks	.17	.19	.26	.19	.19	.21	.23	.20
Tops and trash to stalks...	.67	.54	.70	.58	.63	.66	.66	.63
Tops, trash, roots and stubble to stalks	.84	.73	.96	.77	.81	.86	.89	.83

Some interesting calculations can be made from the approximate averages shown above. Thus from the harvest of 100 tons of millable cane stalks with an average moisture content of 70 per cent, 30 tons of dry matter will be found. In the production of these 30 tons, an additional 24.9 tons of non-millable organic matter will have been grown, 18.9 tons of which would be trash and tops, and 6.0 tons of which would be roots and stubble. These 6 tons (dry weight) of roots and stubble should be equivalent to between 10 and 12 tons green weight, and this represents the amount of organic matter (green weight) left behind in the soil when 100-ton crops of cane are harvested—probably not less than one ton of green roots and stubble left in the soil as organic matter from each 10 tons of cane stalks harvested.

Although tops and trash weights were not kept separately, it is believed that the trash or dry leaves collected during the 12 months before harvest represented fully 75 per cent of the combined weights which were recorded for both trash and

tops at harvest. Hence somewhere in the neighborhood of 1.4 tons of dry trash would be accumulated in 12 months for each 10 tons of stalks harvested. Some of these dry leaves would be in various stages of decomposition and thus be a source of additional organic material to supplement the soil's humus supply.

Summary

A study has been made of the manner in which three different cane varieties have reacted to and utilized differences in their supply of available nitrogen.

Most of the crop characteristics which were measured showed that differences in the available nitrogen supply affected the varieties somewhat differently. For instance, significant interactions between varieties and their nitrogen supplies were found for each of the following: (1) green weight of millable stalks, (2) dry weight of stalks, (3) per cent nitrogen in juice, (4) juice purity, (5) recoverable sugar, (6) total nitrogen in stalks, (7) dry weight of tops and trash, (8) per cent N in tops and trash, (9) total nitrogen in tops and trash, (10) total nitrogen in roots and stubble, (11) total dry weight of entire crop, and (12) total nitrogen recovered in entire crop.

Varieties were apparently not influenced differentially by amounts of nitrogen, in their (1) per cent moisture in green weight of stalks, (2) juice extraction, (3) Brix and pol of juice, (4) yield per cent cane, (5) dry weight of roots and stubble, and (6) per cent N in roots and stubble.

32–8560 produced the highest sugar yield and did so from a medium or average nitrogen level. Its greater efficiency in using the more limited amounts of nitrogen is seen in the fact that it produced from its very low nitrogen supply an amount of sugar very close to that produced by H 109 at the average nitrogen level, and identical with that by 35–1515 at the high level. Also from its low nitrogen level, 32–8560 produced a comparable amount of sugar as H 109 did when this latter cane received the highest amount of nitrogen.

The fact that 32–8560, unlike the other two varieties, did not produce more cane when its nitrogen level was raised from the average to the high level eliminates the possibility of a deficiency in the nitrogen supply as the cause, and suggests some sort of a depressing effect on the growth of this cane when its nitrogen supply is too high.

Distinctive differences in the distribution of their total nitrogen supply between their stalks, tops and trash, and roots and stubble were found in these varieties.

Incidental to the main objectives of this study, we have recorded certain general data for which there is often an inquiry. For instance, the total dry weight which has been produced by these crops in 12 months was made up of approximately 55 per cent stalks, 34 per cent trash and tops, and 11 per cent roots and stubble. Other relationships indicate that approximately 83 pounds of non-millable dry organic matter would be grown for every 100 pounds of dry weight of stalk developed in 12 months: 63 pounds of this in the tops and trash and 20 pounds in the roots and stubble.

Sugar Prices

96° CENTRIFUGALS FOR THE PERIOD
SEPTEMBER 16, 1945, TO DECEMBER 15, 1945

Date	Per pound	Per ton
Sept. 16, 1945—Dec. 15, 1945	3.75¢	$75.00

THE HAWAIIAN PLANTERS' RECORD

EXPERIMENT STATION STAFF

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